Messrs. Ministry of Land, Infrastructure, Transport and Tourism,

Maritime Bureau, Inspection and Measurement Division

Ballast Water Management System
Report of Onboard Test Results

January 22, 2010

JFE Engineering Corporation

Contents

Note) In the text, the following expressions are used:
NaOCl (sodium hypochlorite) means TG Ballastcleaner®.
Na_2SO_3 (sodium sulfite) means TG Environmentalguard®.

Introduction

An "onboard test" of the JFE Ballast Water Management System, as provided in the "Ballast Water Management Systems Model Examination Test Standard," was completed. The results of the onboard test are reported herein.

(1) Test period
January 21-July 25, 2009

(2) The following are the dates of test cycles in which treated ballast water satisfied Regulation D-2, Ballast Water Performance Standard, of the International Convention for the Control and Management of Ships' Ballast Water and Sediments in 3 continuous valid test cycles.

No. 1 cycle Uptake: July 18, 2009, discharge, July 20, 2009
No. 2 cycle Uptake: July 19, 2009, discharge: July 21, 2009
No. 3 cycle Uptake: July 20, 2009, discharge: July 22, 2009

(3) Treatment rate capacity, TRC, of object equipment of application before test
The rated treatment capacity of the equipment in this application is 1,050 m^3/h.

Outline of Ballast Water Management System

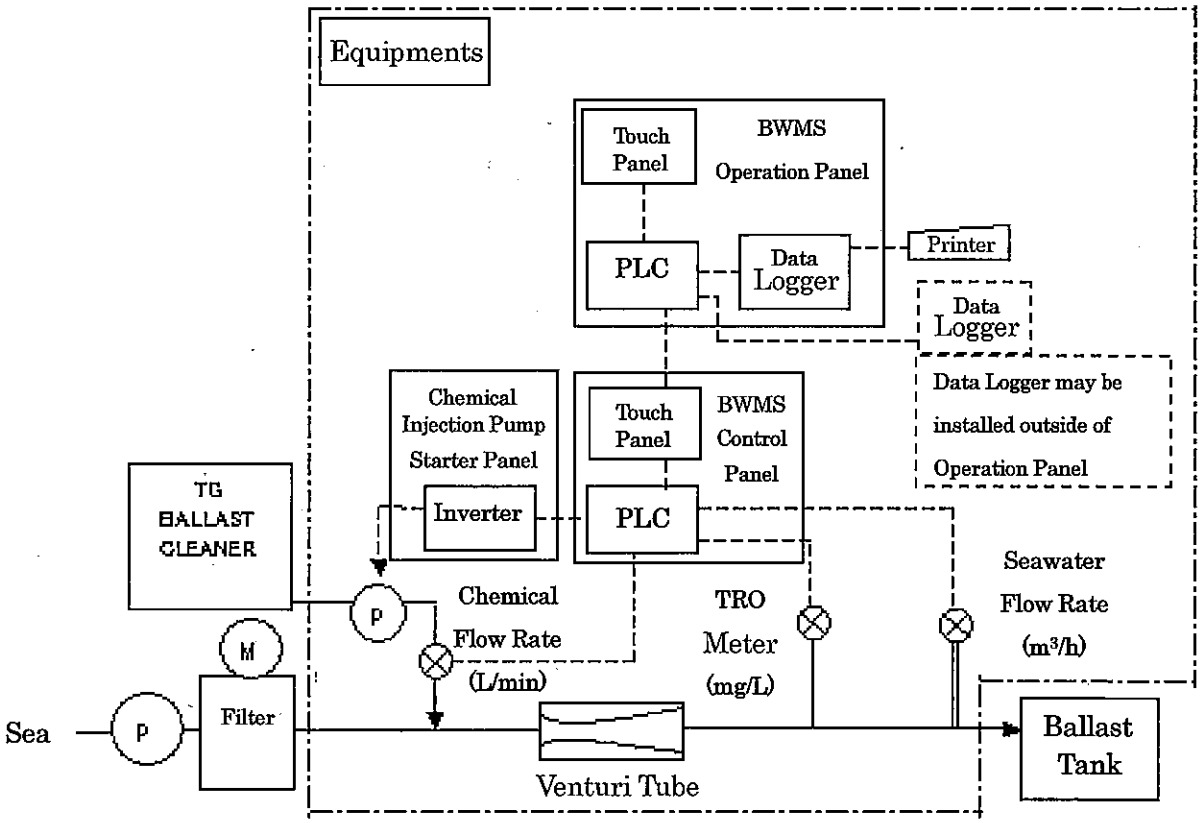


Fig. 1 Ballast Water Uptake System Configuration Diagram

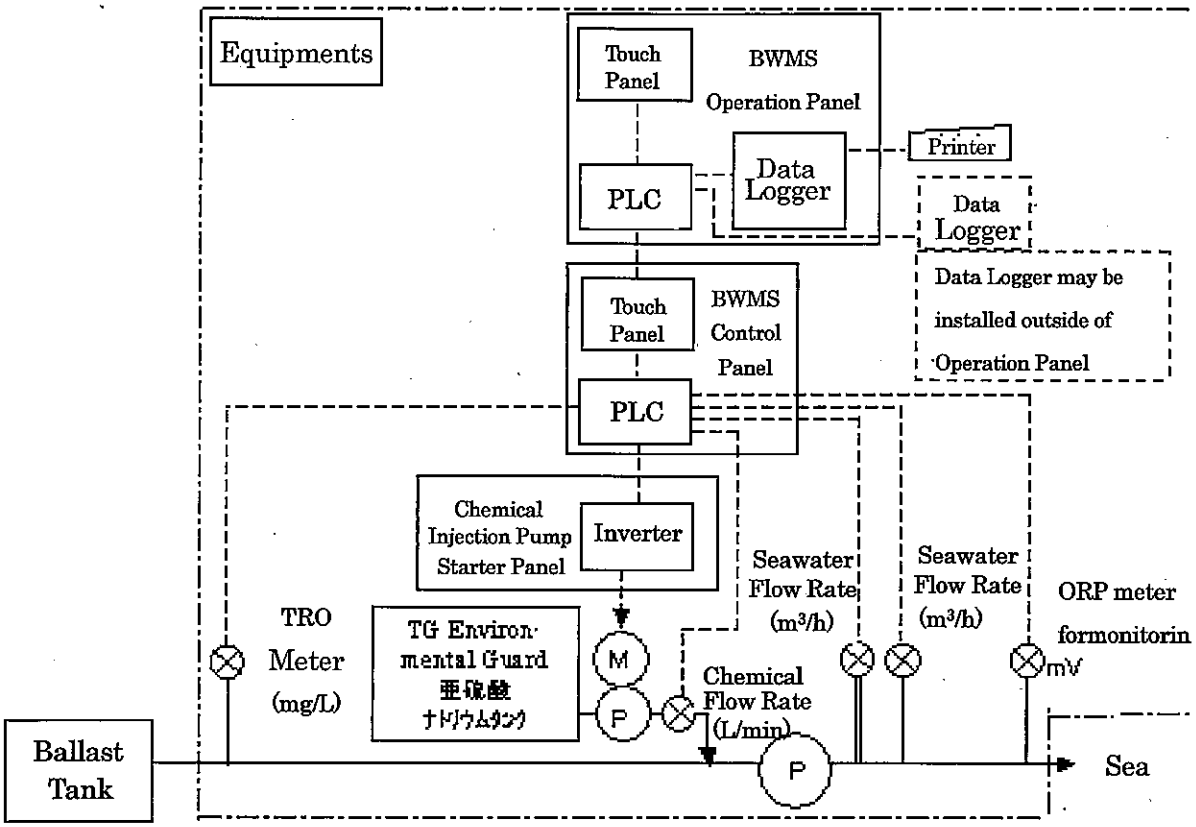


Fig. 2 Ballast Water Uptake System Configuration Diagram

The details of this onboard test are described in the following.

1. Experimental Equipment

(1) Outline of Experimental Ship

This experiment was performed using a JFE-BWMS ballast water management system for onboard test use (hereinafter, abbreviated BWMS) installed on the SAGA PIONEER, a ship registered in Hong Kong. An outline of the experimental ship is presented below.

Ship name: M.V. SAGA PIONEER
Ship type: Box Shape Bulker
Ship owner: SAGA Shipholding (Norway) AS
Shipbuilder: Ohshima Shipbuilding Co., Ltd.
Date delivered: August 4, 2008
Main specifications

LOA	199.20 m
LPP	190.00 m
Breadth	30.50 m
Depth	16.40 m
Draft (summer)	11.80 m
Service speed	14.9 knot
Deadweight (summer)	46,822 MT

General view of SAGA PIONEER

The ballast tanks of the experimental ship are F.P.T., A.P.T, and No. 1, 12 B.W.T.(C), and No. 2-11(P)/(S) B.W.T. The capacities of the ballast tanks are shown in Table 1.

Table 1 Ballast tank capacity

Tank Name	Side	Volume (m^3)	Tank Name	Side	Volume (m^3)	Tank Name	Side	Volume (m^3)
F.P.T.	C	1385.9	No.5W.B.T.	P	746.2	No.9W.B.T.	P	684.9
No.1 W.B.T	C	1640.3	No.5 W.B.T.	S	746.2	No.9W.B.T.	S	684.9
No.2 W.B.T.	P	343.4	No.6 W.B.T.	P	746.6	No.10W.B.T.	P	410.9
No.2 W.B.T.	S	343.4	No.6 W.B.T.	S	746.6	No.10W.B.T.	S	410.9
No.3 W.B.T.	P	595.8	No.7 W.B.T.	P	746.2	No.11W.B.T.	P	597.0
No.3 W.B.T.	S	595.8	No.7 W.B.T.	S	746.2	No.11W.B.T.	S	597.0
No.4 W.B.T.	P	742.0	No.8 W.B.T.	P	746.2	No.12W.B.T.	C	443.7
No.4 W.B.T.	S	742.0	No.8 W.B.T.	S	746.2	A.P.T	C	428.4

In the onboard test which began in January 2009, No. 12 WBT was used as a treated water tank. In the continuous onboard test cycles at the Port of Kobe in July 2009, the test cycles were performed using No. 6, 8, and 11 W.B.T. as one group (2089.8 m^3/side) and No. 5, 7, and 10 W.B.T. as another group (1903.3 m^3/side).

(2) Ballast Water Management System

(2-1) Pump and Piping System

A diagram of the piping system for installation of the BWMS used in the test on the SAGA PIONEER is shown in Annex－1.

In normal ballast operation of this ship, F.P.T. and No. 2-11(S) B.W.T. are operated using No. 1 ballast pump, and No. 1.2-11(P).12 B.W.T. and A.P.T are operated using No. 2 ballast pump. The BWMS was installed in the system of No. 2 ballast pump.

In the onboard test, the ballast tanks in the system of No. 1 ballast pump were used as control water (untreated water used for comparison purposes), and the ballast tanks in the system of No. 2 ballast pump were used as treated water (ballast water treated by BWMS). For the capacities of these tanks, see Table 1.

It should also be noted that a ballast booster pump was installed to compensate for head loss due to installation of the BWMS.

(2-2) Sampling Devices

Sampling was performed at locations S1 and S2 in the piping system diagram (Annex－1).

Drawings of the sampling devices are shown below.

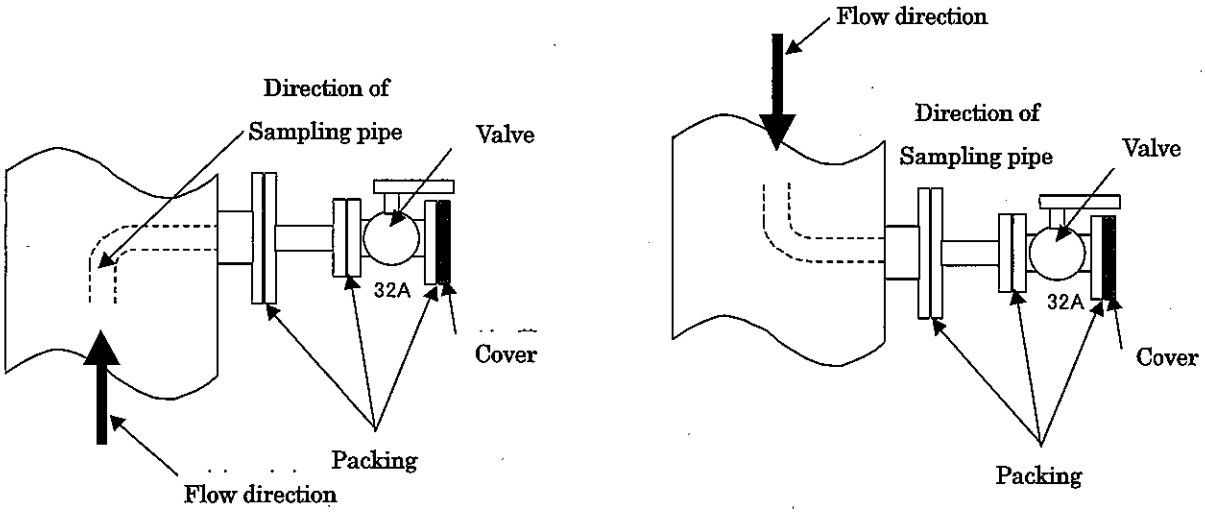
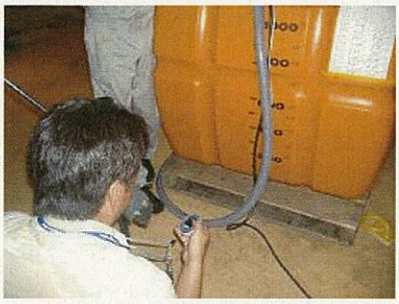


Fig-1 Sampling devices

As isokinetic sampling was assumed, the sampling rate was 1,050 m^3/h x10/920=11.4 m^3/h=190 L/min as calculated from the cross-sectional area ratio of the main ballast pipe, 922 cm^2 and the sampling pipe, 10 cm^2. The flow rate was adjusted to take a sample of 1 m^3 of ballast water in approximately 5.8 minutes.

In the continuous onboard test cycles at the Port of Kobe in July 2009, water samples could not be taken during discharge when operating at 1,050 m^3/h, as negative pressure was generated at the sampling position. Therefore, confirmation operation was performed at 1,050 m^3/h for 10min, and operation was performed at 700 m^3/h during sampling at other times. In this case, the sampling time was approximately 8.6 min.



Sampling time control

2. Content of Onboard Test

2.1 Continuous Test Cycles in Port of Kobe

(1) Test Cycle

One test cycle was performed as follows. See also the piping system diagram in Annex－1.

1) Uptake of ballast treatment water (solid red line)

No. 2 ballast pump was started. The ballast booster pump was also started. Treatment was performed during ballast water uptake by passing the ballast water through the respective processes of the BWMS filter, injection of sodium hypochlorite from the nozzle, and the Venturi tube. The treated ballast water was then pumped to the ballast treated water tank.

2) Uptake of control water (dotted red line)

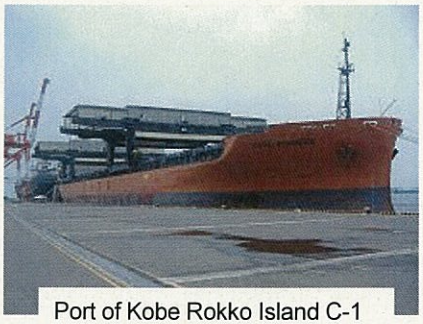
No. 1 ballast pump was started, and ballast water was pumped to the ballast control water tank while taking samples from the sampling line.

3) Discharge of ballast treated water (solid blue line)

In order to discharge the treated water held in the ballast treated water tank, the treated water was pumped from the treated water tank using No. 2 ballast pump. In this process, the remaining chlorine in the treated water was neutralized by injecting sodium sulfite from the nozzle on the upstream side (suction side) of the ballast pump. After neutralization, the treated water was discharged overboard while taking samples from the sampling line.

4) Discharge of control water (dotted blue line)

In parallel with discharge of the ballast treated water, the control water was pumped from the ballast control water tank by No. 1 ballast pump, and was discharged overboard while taking samples from the sampling line.



Port of Kobe Rokko Island C-1

Mooring condition of ship

The test cycles were performed with the test ship in a moored condition at Rokko Island Public Wharf C-1 at the Port of Kobe. The test cycles were performed with No. 6, 8, and 11 WBT as one group, and No. 5, 7, and 10 WBT as another group.

(2) Measurements and Records

The following records were taken in connection with the ballast water.

- Amount and location of uptake and discharge
- Time of sampling (start and finish times)

For details, see the following:

Annex－2 Sampling Timing Chart

Annex－3 Record of Uptake and Discharge

Record-keeping in control room

The following records were also taken using the BWMS data logger.

- Various parameters, including control, monitoring, flow rate, etc.

For details, see Annex －4:

Annex－4 Data Logger Record of BWMS Onboard Test

(3) Sampling Methods and Amount of Water

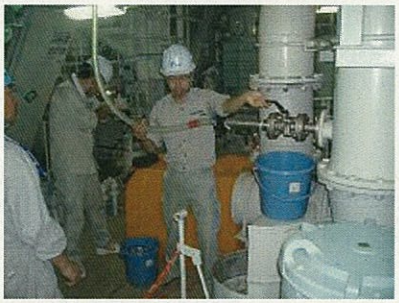
All sampling was performed in parallel during ballast uptake and discharge.

The contents of the samples were as follows.

S1 : Ballast control water 3 samples of control water during ballast uptake and discharge
(1 time each during 1st half, middle part, and 2nd half of uptake and discharge)

S2 : Ballast treated water 9 samples of neutralized treated water during ballast water discharge
(3 times each during 1st half, middle part, and 2nd half of discharge)

- Samples were taken using the sampling device for control water on the lower deck and sample device for treated water on the 3rd deck. The samples were transferred by hose and temporarily stored as-sampled in buffer tanks on the 2nd deck. In order to take plankton counts and water quality data, 1.1 m^3 of sample water was collected in the buffer tanks in 1 sampling operation. An image of the sampling and concentration procedures is



Control water sampling on lower deck

Treated water sampling on 3rd

shown in the following figure.

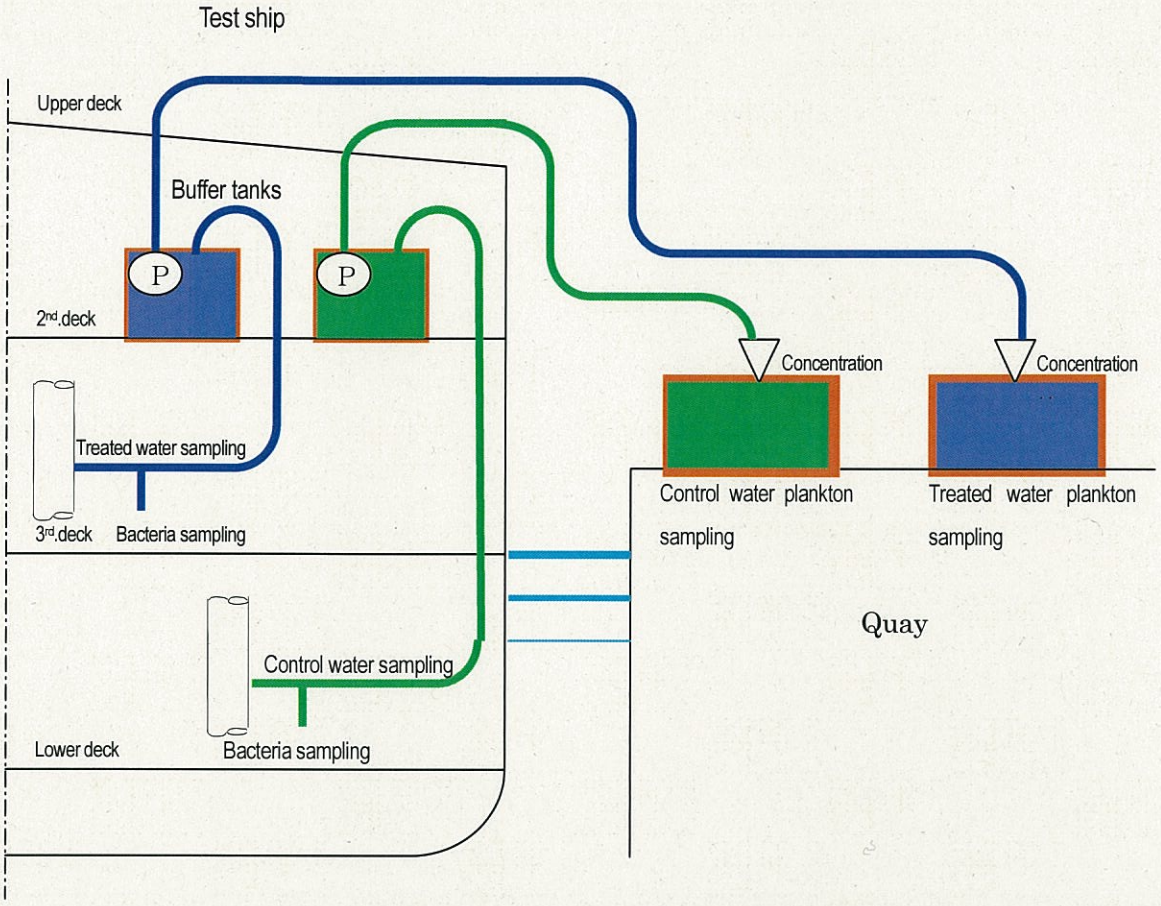
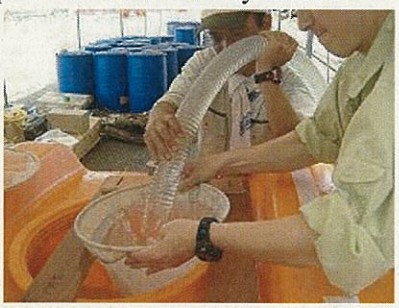


Fig-2 Image of sampling and concentration

- In order to count viable organisms with a minimum size of 50 μm or larger, samples were transferred by hose to the quay via the upper deck by way of an underwater pump, and were then concentrated on the quay by passing through a net with a 35 μm mesh. The concentrated water captured by the net was observed with a microscope and organisms were counted.

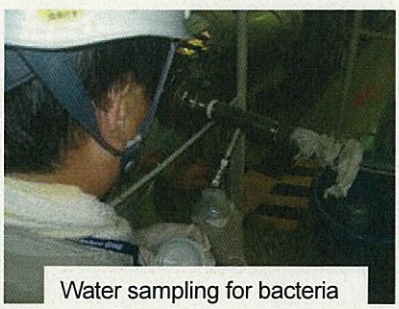
Pumping from 2nd deck (attachment room)



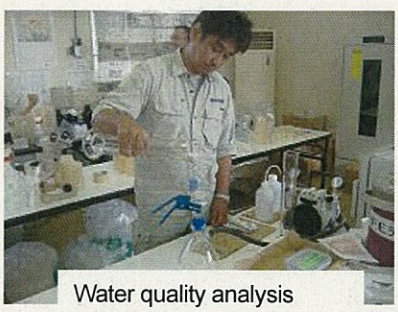
Concentration on quay

Water which passed through the net was stored in a 1 m^3 tank. This completed one sampling operation.
To avoid contamination, the pumps, hoses, and tanks used in the sampling operation were clearly identified as for use with treated water or use with control water, and were used appropriately.

- In order to detect viable organisms with sizes from ≧10 to <50 μm, water samples were collected in 1 L plastic bottles. Sampling was performed at the outlet of the hose leading to the quay. For organism counts, the samples were



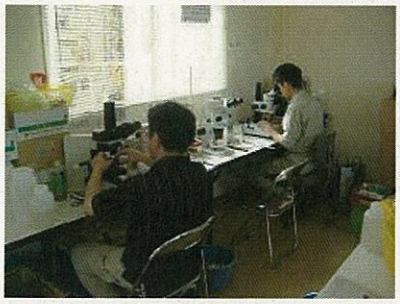
Water sampling for bacteria



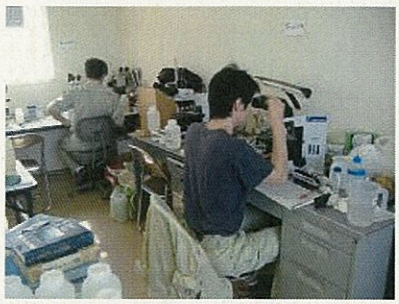
Water quality analysis

concentrated using a net with a 7 μm mesh.

- For evaluation of bacteria, water samples were collected in 500 mL sterilized bottles. The water samples were taken from a branch pipe on the sampling device attached to the ballast pipe.



Counting L size plankton



Counting S size plankton

(4) Analysis of Samples

Chlorine concentration, temperature, particulate organic carbon concentration, and total suspended solids were recorded for all samples.

Bioassays were performed by the following procedures:

1) During ballast uptake, the concentration of living organisms in the control water was checked to determine whether the concentration was 10 times or more than the standard value for ballast water discharge (S1).

2) During ballast discharge, the concentration of living organisms in the control water checked to determine whether the concentration was equal to or larger than the standard value for ballast water discharge (S1).

Bacteria culture

Formed colonies (control water)

Counting colonies

3) During ballast discharge, the concentration of living organisms in the treated water was checked to determine whether the concentration satisfied the standard value for ballast water discharge (S2).

(5) Results

- Judgment standard

"It shall be confirmed that the test cycle from ballast water uptake through discharge satisfies the standard values for ballast water discharge in 3 consecutive valid test cycles. Invalid test cycles are not considered to affect continuity."

- Results of this test

In this test, a total of 6 test cycles were performed. All 6 cycles were valid cycles, and it was confirmed that the cycles satisfied the standard values for ballast water discharge.

Summary of Test Results

Test cycle		No. 1 cycle	No. 2 cycle	No. 3 cycle	No. 4 cycle	No. 5 cycle	No. 6 cycle
Test date	Uptake	7/18	7/19	7/20	7/21	7/22	7/23
	Discharge	7/20	7/21	7/22	7/23	7/24	7/25
L size plankton (individuals/m^3)	Uptake control water (≧100)	126,200	213,033	97,220	19,740	64,807	27,283
	Discharge control water (≧10)	313,933	89,580	34,310	177,267	65,710	50,987
	Discharge treated water (<10)	2	0	0	0	0	0
S size plankton (individuals/ml)	Uptake control water (≧100)	1,022	1,413	1,330	760	1,140	807
	Discharge control water (≧10)	1,043	1,063	733	630	747	117
	Discharge treated water (<10)	0	0	0	0	0	0
E. coli (cfu/100 ml)	Uptake control water	7	21	31	5	20	30
	Discharge control water	6	6	6	3	4	12
	Discharge treated water (<250cfu)	0	0	0	0	0	0
Intestinal *Enterococci* (cfu/100 ml)	Uptake control water	25	44	37	47	62	9
	Discharge control water	2	4	2	1	1	2
	Discharge treated water (<100cfu)	0	0	0	0	0	0
Toxicogenic *Vibrio* cholerae (cfu/100 ml)	Uptake control water	0	0	0	0	0	0
	Discharge control water	0	0	0	0	0	0
	Discharge treated water (<1cfu)	0	0	0	0	0	0
Pass or fail	(Valid cycle standard) (Treatment standard)	Pass	Pass	Pass	Pass	Pass	Pass

2.2 System Operation Period

Monitoring by data logger was performed for a period of 6 months. The starting date of this period was the first ballast treatment (January 21, 2009) after the chemicals were loaded. The ending date was the final day (July 25, 2009) of the test cycles in the Port of Kobe.

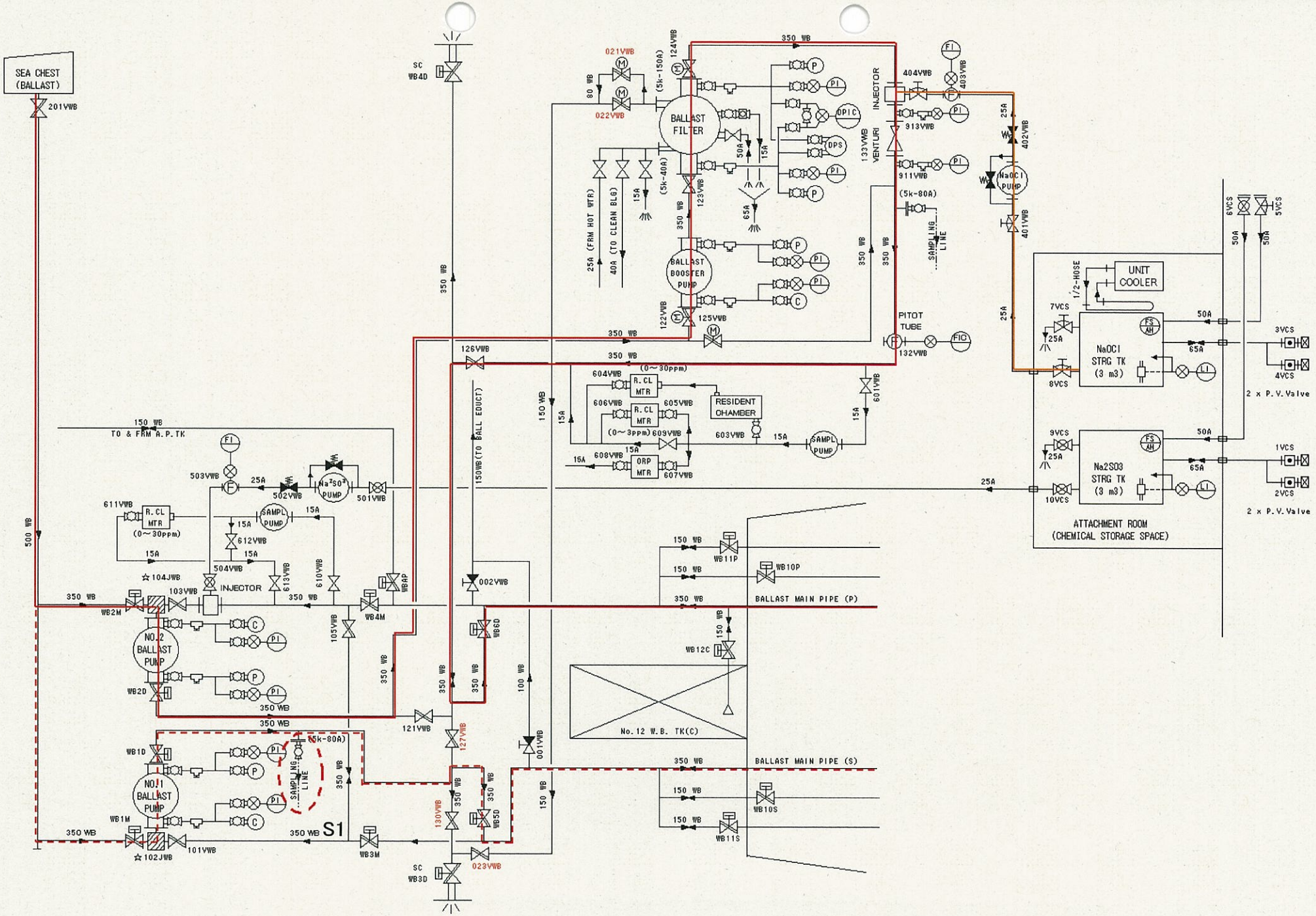
2.3 Overall Test Schedule

The overall test schedule is shown in Annex－5 Overall Schedule of Onboard test.2.4 Results of Preliminary Inspections before Onboard Test

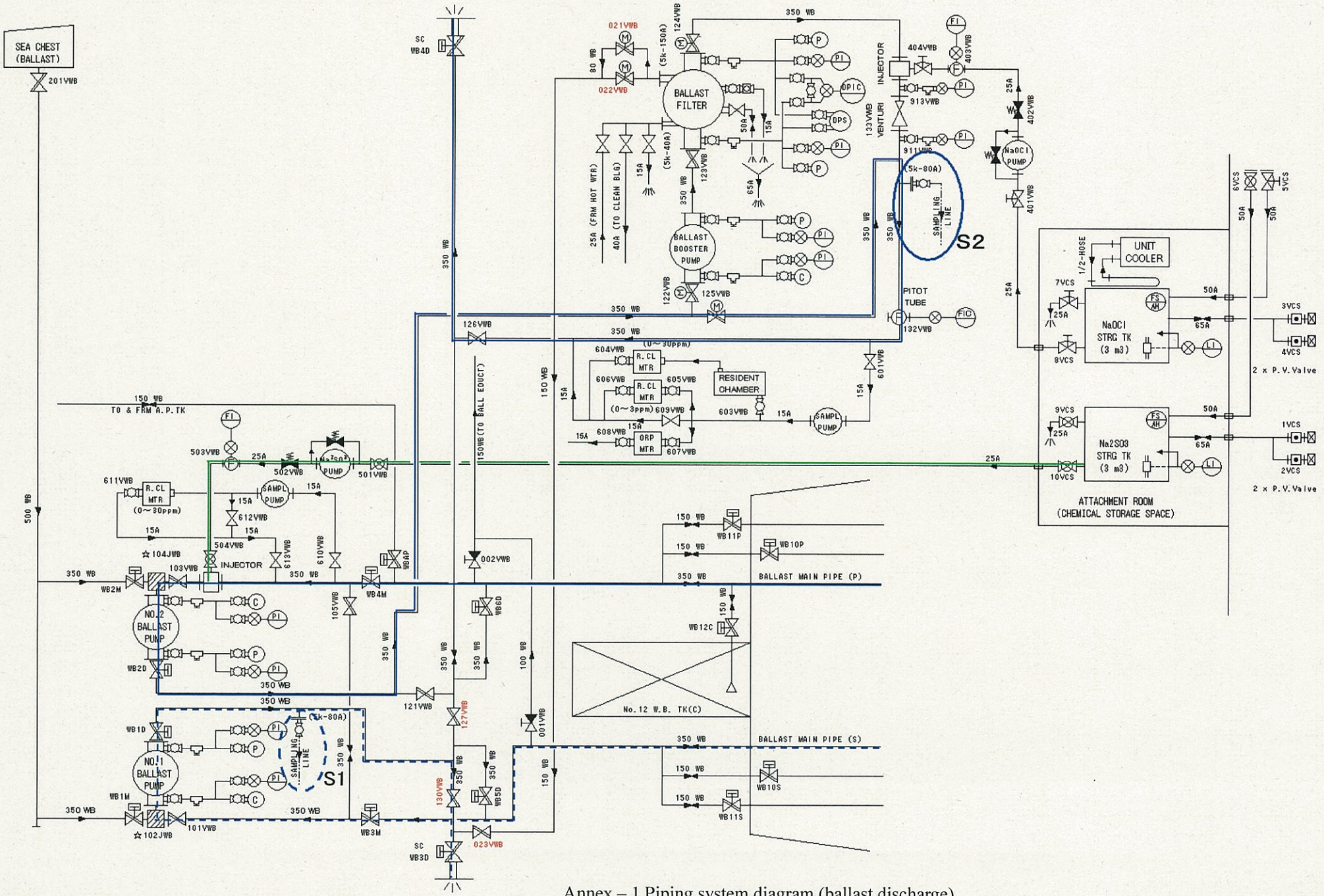
Before the start of the onboard test, various "preliminary inspections before onboard test," beginning with an inspection of the external appearance of the equipment, were performed by Ohshima Shipbuilding Co., Ltd., which installed the equipment of the BWMS.
For details, see Annex－6, Results of Preliminary Inspections before Onboard Test.

2.5 Results of Biological and Other Measurements

Measurements of organisms, bacteria, and water quality were performed in the continuous cycle test.
For details, see Annex－7 Results of Biological and Other Measurements.

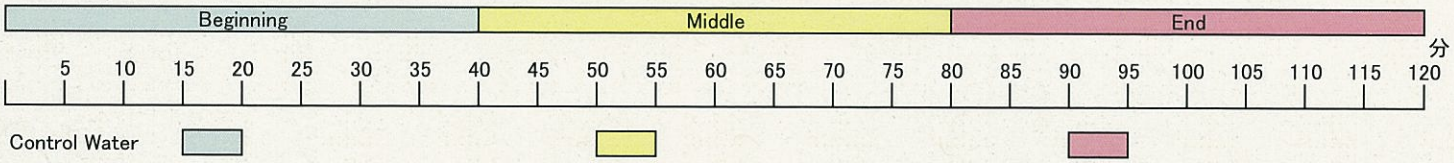


Annex – 1 Piping system diagram (ballast uptake)

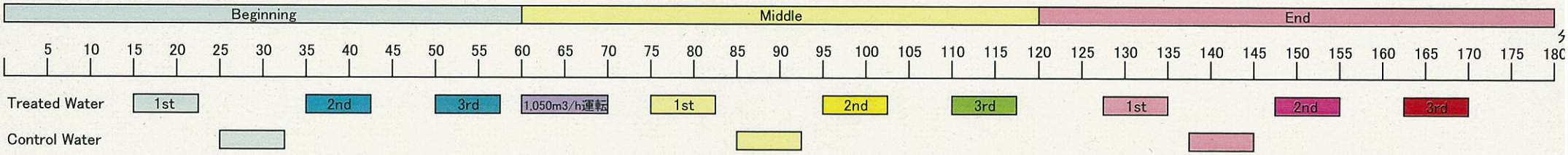


Annex – 1 Piping system diagram (ballast discharge)

Uptake of Ballast Wate (Operated at 1,050m3/h)



Discharge of Treated B.W. (Operated at 700m3/h and 1,050m3/h for 10 minuites)



Annex – 2 Sampling timing chrart of sample correction

A. Mechanical

1. External Appearance

The external appearance and structure of the equipment shall be confirmed, referred to the relevant specifications and drawings.

2. Dimensional Inspection

The dimensions of the equipment shall be confirmed, referred to the relevant specifications and drawings.

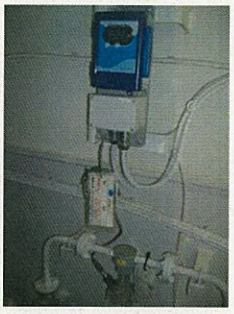
3. Confirmation of Markings

Proper marking of all necessary items shall be confirmed.

Examples of markings

NaOCl injector

Venturi Tubes



TRO Meter

Test Results

No.	Equipment name	Date	Appearance	Dimensions	Marking
1.	BALLAST FILTER	08/06/30	OK	OK	OK
2.	VENTURI	08/06/30	OK	OK	OK
3.	NaClO PUMP	08/06/30	OK	OK	OK
4.	NaClO INJECTOR	08/06/30	OK	OK	OK
5.	Na_2SO_3 PUMP	08/06/30	OK	OK	OK
6.	Na_2SO_3 INJECTOR	08/06/30	OK	OK	OK
7.	BALLAST WATER FLOW MTR.	08/06/30	OK	OK	OK
8.	NaClO FLOW MTR.	08/06/30	OK	OK	OK
9.	Na_2SO_3 FLOW MTR.	08/06/30	OK	OK	OK
10.	TRO METER 1 (0-30ppm)	08/06/30	OK	OK	OK
11.	TRO METER 2 (0-30ppm)	08/06/30	OK	OK	OK
12.	TRO METER 3 (0-3ppm)	08/06/30	OK	OK	OK

Annex-3 Records of Uptake and Discharge

Cycle No. Test cycle-1
Tank Group No.6,8,11
Ballast Volume 2089.8m^3 × P/S
Sampled Volume 1.1 m^3
Record of uptake (Operation at 1,050m^3/h)
Date 18th July 2009 (Sat.)

		Control(S)	Treated(P)
Ballashing start time		13:22:00	13:24:55
Beg.	Sampling start time	13:42:30	
	Sampling end time	13:49:20	
Mid.	Sampling start time	14:13:15	
	Sampling end time	14:18:55	
End	Sampling start time	14:40:20	
	Sampling end time	14:45:55	
Ballasting end time		15:49:50	15:55:30

Record of de-ballasthing
Date 20th July 2009 (Mon.)

		Control(S)	Treated(P)		
De-ballashing start time		8:48:24	8:49:30		
			1st	2nd	3rd
Beg.	Sampling start time	9:14:40	9:05:03	9:24:30	9:39:00
	Sampling end time	9:22:34	9:13:00	9:32:50	9:47:45
Mid.	Sampling start time	10:04:40	9:55:00	10:14:50	10:30:40
	Sampling end time	10:13:05	10:03:22	10:23:40	10:39:10
End	Sampling start time	11:00:10	10:49:50	11:10:40	11:26:50
	Sampling end time	11:09:20	10:58:15	11:19:00	11:35:00
De-ballasting end time		11:50:05	11:59:00		

Cycle No. Test cycle-2
Tank Group No.5,7,10
Ballast Volume 1903.3m^3 × P/S
Sampled Volume 1.1 m^3
Record of uptake (Operation at 1,050 m^3/h)
Date 19th July 2009 (Sun.)

		Control(S)	Treated(P)
Ballashing start time		13:04:21	13:08:03
Beg.	Sampling start time	13:22:10	
	Sampling end time	13:26:50	
Mid.	Sampling start time	13:50:30	
	Sampling end time	13:56:40	
End	Sampling start time	14:30:00	
	Sampling end time	14:35:25	
Ballasting end time		15:10:00	15:16:53

Record of de-ballasthing
Date 21st July 2009 (Tue.)

		Control(S)	Treated(P)		
De-ballashing start time		9:00:00	9:02:00		
			1st	2nd	3rd
Beg.	Sampling start time	9:26:40	9:16:30	9:37:10	9:53:10
	Sampling end time	9:35:15	9:24:30	9:45:50	10:02:05
Mid.	Sampling start time	10:20:25	10:09:35	10:29:40	10:44:10
	Sampling end time	10:28:25	10:18:15	10:37:40	10:52:20
End	Sampling start time	11:08:40	10:59:00	11:18:50	11:34:25
	Sampling end time	11:16:45	11:07:30	11:27:05	11:42:40
De-ballasting end time		11:57:00	12:07:00		

Cycle No. Test Cycle-3
Tank Group No.6,8,11
Ballast Volume 2089.8m^3×P/S
Sampled Volume 1.1m^3
Record of uptake (Operation at 1,050m^3/h)
Date 20th Jul 2009 (Mon.)

		Control(S)	Treated(P)
Ballashing start time		13:37:00	13:40:30
Beg.	Sampling start time	13:52:30	
	Sampling end time	13:58:20	
Mid.	Sampling start time	14:23:00	
	Sampling end time	14:29:05	
End	Sampling start time	15:09:30	
	Sampling end time	15:15:25	
Ballasting end time		16:05:20	15:55:00

Record of de-ballasthing (9:44:50～9:54:50 Operation at 1,050m^3/h)
Date 22nd July 2009 (Wed.)

		Control(S)	Treated(P)		
De-ballashing start time		8:45:00	8:48:00		
			1st	2nd	3rd
Beg.	Sampling start time	9:10:20	9:01:00	9:20:30	9:34:30
	Sampling end time	9:19:05	9:09:00	9:28:40	9:42:36
Mid.	Sampling start time	10:10:00	9:59:00	10:22:00	10:37:20
	Sampling end time	10:18:43	10:07:50	10:30:36	10:46:04
End	Sampling start time	11:03:00	10:53:20	11:12:20	11:28:20
	Sampling end time	11:11:08	11:01:30	11:20:25	11:36:24
De-ballasting end time		11:44:20	11:53:00		

Cycle No. Test cycle-4
Tank Group No.5,7,10
Ballast Volume 1903.3m^3×P/S
Sampled Volume 1.1m^3
Record of uptake (Operation at 1,050m^3/h)
Date 21st July 2009 (Tue.)

		Control(S)	Treated(P)
Ballashing start time		13:27:18	13:29:23
Beg.	Sampling start time	13:40:35	
	Sampling end time	13:46:36	
Mid.	Sampling start time	14:15:00	
	Sampling end time	14:21:05	
End	Sampling start time	14:55:00	
	Sampling end time	15:01:05	
Ballasting end time		15:27:00	15:29:15

Record of de-ballasthing (9:57:40～10:07:40 Operation at 1,050m^3/h)
Date 23rd July 2009 (Thu.)

		Control(S)	Treated(P)		
De-ballashing start time		8:47:00	8:50:00		
			1st	2nd	3rd
Beg.	Sampling start time	9:18:43	9:07:15	9:30:02	9:46:02
	Sampling end time	9:27:02	9:16:12	9:39:12	9:54:35
Mid.	Sampling start time	10:22:03	10:11:04	10:33:00	10:49:04
	Sampling end time	10:30:49	10:19:57	10:41:34	10:58:10
End	Sampling start time	11:48:14	11:06:02	11:21:43	11:37:18
	Sampling end time	11:56:44	11:14:50	11:30:38	11:45:50
De-ballasting end time		12:20:00	12:11:00		

Cycle No. Test cycle-5
Tank Group No.6,8,11
Ballast Volume 2089.8m^3×P/S
Sampled Volume 1.1m^3
Record of uptake (Operation at 1,050m^3/h)
Date 22nd July 2009 (Wed.)

		Control(S)	Treated(P)
Ballashing start time		13:16:20	13:19:00
Beg.	Sampling start time	13:30:00	
	Sampling end time	13:36:10	
Mid.	Sampling start time	14:05:00	
	Sampling end time	14:11:30	
End	Sampling start time	14:40:00	
	Sampling end time	14:46:05	
Ballasting end time		15:20:00	15:35:20

Record of de-ballasthing (9:38:00～9:48:00 Operation at 1,050m^3/h)
Date 24th July 2009 (Fri.)

		Control(S)	Treated(P)		
De-ballashing start time		8:37:00	8:40:00		
			1st	2nd	3rd
Beg.	Sampling start time	9:04:20	8:54:50	9:13:30	9:28:30
	Sampling end time	9:12:22	9:03:08	9:21:35	9:36:42
Mid.	Sampling start time	10:01:40	9:52:00	10:11:40	10:27:00
	Sampling end time	10:10:11	10:00:06	10:20:05	10:35:12
End	Sampling start time	10:53:15	10:42:00	11:03:15	11:18:20
	Sampling end time	11:01:24	10:51:08	11:11:25	11:26:26
De-ballasting end time		11:47:18	11:50:20		

Cycle No. Test cycle-6
Tank Group No.5,7,10
Ballast Volume 1903.3m^3×P/S
Sampled Volume 1.1m^3
Record of uptake (Operation at 1,050m^3/h)
Date 23rd July 2009 (Thr.)

		Control(S)	Treated(P)
Ballashing start time		13:36:30	13:39:00
Beg.	Sampling start time	13:52:04	
	Sampling end time	13:57:55	
Mid.	Sampling start time	14:25:00	
	Sampling end time	14:31:05	
End	Sampling start time	15:00:00	
	Sampling end time	15:05:51	
Ballasting end time		15:33:30	15:29:15

Record of de-ballasthing (9:40:30～9:50:30 Operation at 1,050m^3/h)
Date 25th July 2009 (Sat.)

		Control(S)	Treated(P)		
De-ballashing start time		8:38:30	8:39:30		
			1st	2nd	3rd
Beg.	Sampling start time	9:03:30	8:54:00	9:13:00	9:28:15
	Sampling end time	9:11:50	9:02:18	9:21:18	9:36:24
Mid.	Sampling start time	10:04:25	9:54:40	10:14:30	10:30:10
	Sampling end time	10:13:05	10:03:05	10:23:18	10:38:15
End	Sampling start time	10:55:00	10:45:00	11:05:00	11:20:00
	Sampling end time	11:03:13	10:53:05	11:13:06	11:28:08
De-ballasting end time		11:49:30	11:46:00		

Process Chart of Onboard Test Cycles

July 16th (Thu..)	Arrival of Equipmenta	Work by Japan Lent All Co.		Set up of Tent at Quay				Installation of Air Conditioner in Marine House		Installation of Tables, Chairs and Copying Machine in Marine House										
	9:00	of Equipments from YOKOHAMA		NaOCL 2,000 L		Na2SO3 4,000 L		Underwater Pump, Hose		perimental Equipments (Incubator etc).										
July 17th (Fri.)	Arrival in Port 10:00	Loading of Equipments and Unloading of !m3 Tanks						Installation of 1m3 Capacity Tanks		Hose Sets		Elements by Fresh Water								
		Take out of NaOCl in Tank				Loading of New NaOCl		Addition of Na2SO3											*1: Uptake *2: Dischrge	
		Tank No. (group A)	6, 8, 11 (Total 2142.1m3)						Tank No. (group B)	5, 7, 10 (Total 1951.0m3)							No. of Samples	
		Work Item	Beginning		Middle		End		Work Item	Beginning		Middle		End			●	○
			Control	Treated	Control	Treated	Control	Treated		Control	Treated	Control	Treated	Control	Treated		UT*1	DC*2
July 18th (Sat.)	9:00–13:30	Stripping Discharge																
	14:00–17:00	Uptake (Cycle 1)	●		●		●										3	
18th (Sun.)	9:00–13:30	↓							Stripping Discharge									
	14:00–17:00								Uptake (Cycle 2)	●		●		●			3	
20th (Mon.)	9:00–10:00	Discharge	○	○○○					↓									4
	10:30–11:30	Discharge			○	○○○												4
	12:00–13:00	Discharge (Complete Cycle 1)					○	○○○										4
	14:00–17:00	Uptake (Cycle 3)	●		●		●										3	
21st (Tue.)	9:00–10:00	↓							Discharge	○	○○○							4
	10:30–11:30								Discharge			○	○○○					4
	12:00–13:00								Discharge (Complete Cycle 2)					○	○○○			4
	14:00–17:00								Uptake (Cycle 4)	●		●		●			3	
22nd (Wed.)	9:00–10:00	Discharge	○	○○○					↓									4
	10:30–11:30	Discharge			○	○○○												4
	12:00–13:00	Discharge (Complete Cycle 3)					○	○○○										4
	14:00–17:00	Uptake (Cycle 3)	●		●		●										3	
23rd (Thu.)	9:00–10:00	↓							Discharge	○	○○○							4
	10:30–11:30								Discharge			○	○○○					4
	12:00–13:00								Discharge (Complete Cycle 4)					○	○○○			4
	14:00–17:00								Uptake for Departure									
24th (Fri.)	9:00–10:00	排水	○	○○○														4
	10:30–11:30	排水			○	○○○												4
	12:00–13:00	Discharge (Complete Cycle 5)					○	○○○										4
	14:00–17:00	Uptake for Departure														Total No. of Samples	15	60
25th (Sat.)	Leave Port 16:00？	Loading of the things to be returned to the ship Cleaning																
26th (Sun.)		Pull out tents																
27th (Mon.)																		
28th (Tue)	End of Cultivation	Clean Up in and around Marine House Send Equipments to YOKOHAMA																

Annex-4 Data Logger Records of JFE-BWMS Onboard Tests

1. Onboard Test Duration

Start : 21st January 2009 JFE-BWMS Operation Start
End : 25th July 2009

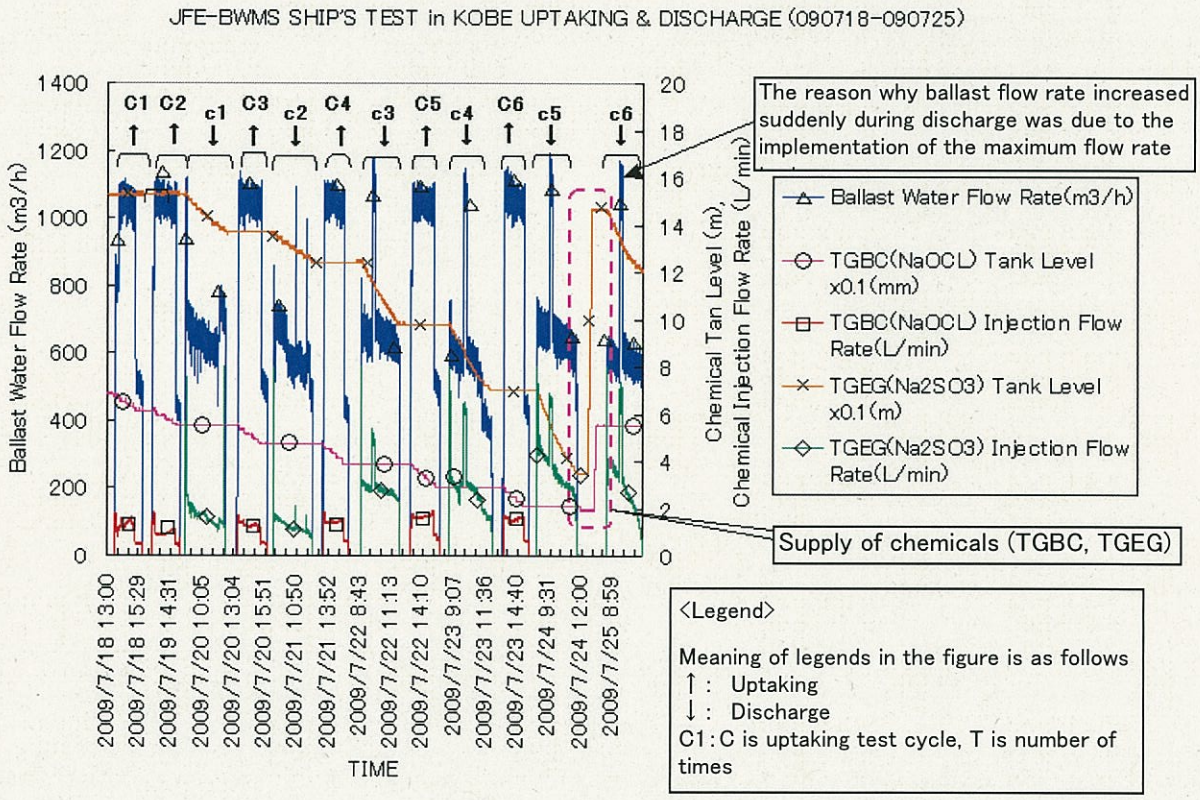
Test Time : 6 month and 4 days

2. Onboard test Impremention Date and Place

Start		End	Country	Place
21st January	~	22nd January	U.S.A.	Mobile
23rd January	~	24th January	U.S.A.	Darrow
16th March	~	18th March	India	Mundra
21st June	~	23rd June	India	Daheji
7th July	~	7th July	Chine	Hong Kong
18th July	~	25th July	Japan	Kobe

3. Test Records at Kobe

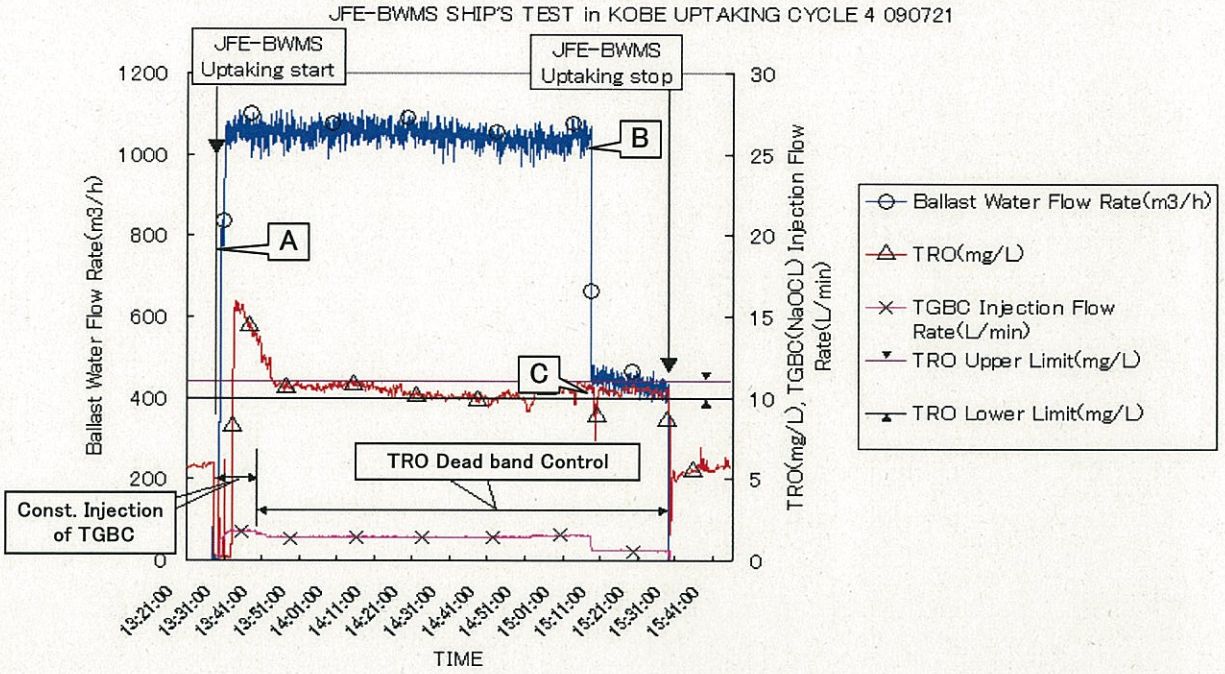
1) After supplying TG Ballastcleaner and TG Environmentalguard in the chemical tanks at Kobe, the uptaking and discharge tests of the onboard tests were implemented from 18th July 2009 to 25th July 2009 (In Japanese time).
All of the trend data of onboard tests are shown below.



4. Records of the tests at Kobe

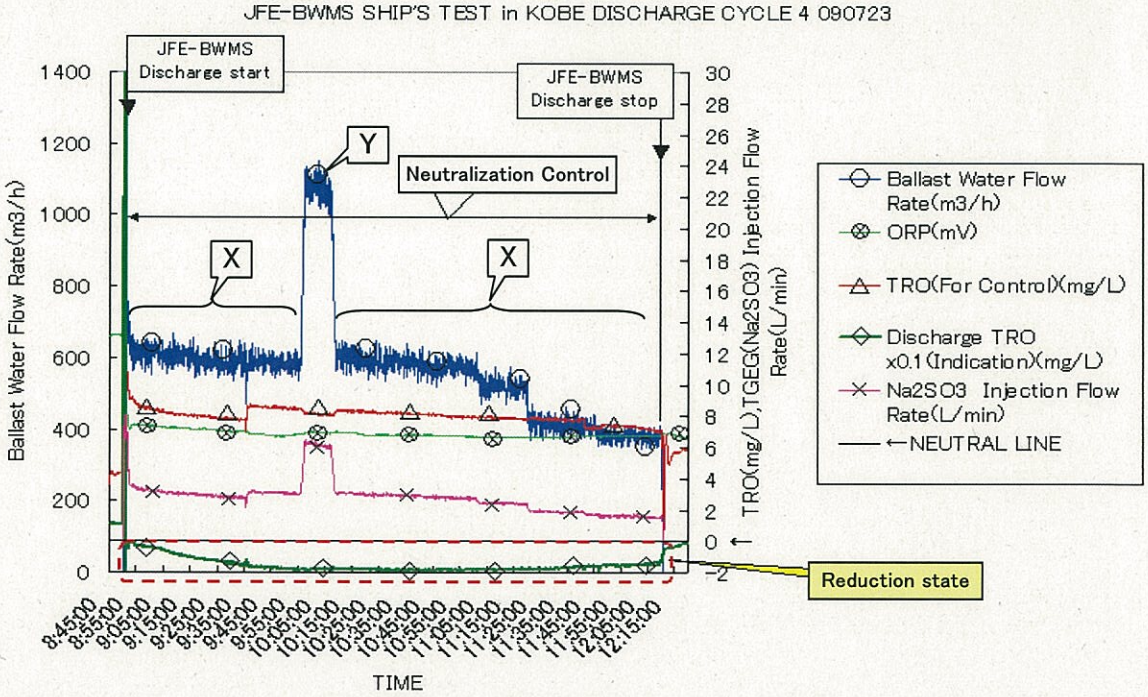
Among the records of onboard tests in Kobe, the trend data of uptakingly (21st July) and discharge (23rd July) are shown below.

21th July 2009 UPTAKING



<Supplemental remarks: A: Ccondition only ballast pump was operating
B: Condition only ballast pump and booster pump were operating
C: #5, 7 Valve closed at ballast tank entry and booster pump shutdown condi

23rd July 2009 DISCHARGE

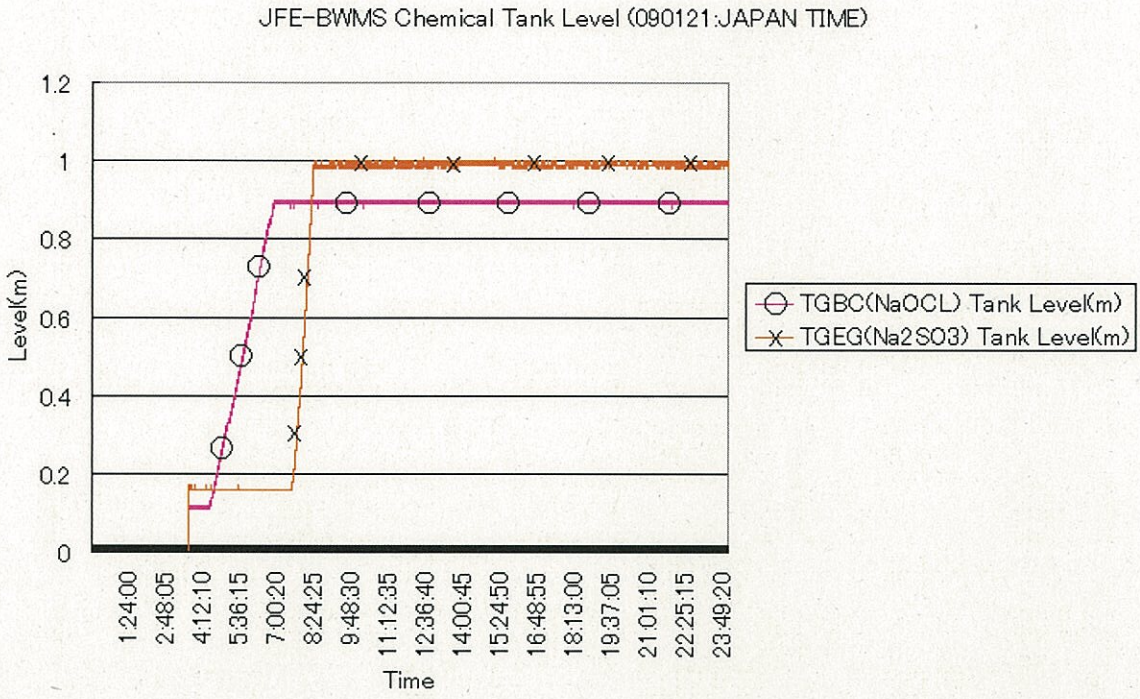


<Supplemental remarks: X : By attenuating the opening of outlet valve, discharging ballast flow rate was adjusted from 600 to 700m3/h
Y : By attenuating the outlet valve, ballast discharging flow rate was increase more than 1,000m^3/h

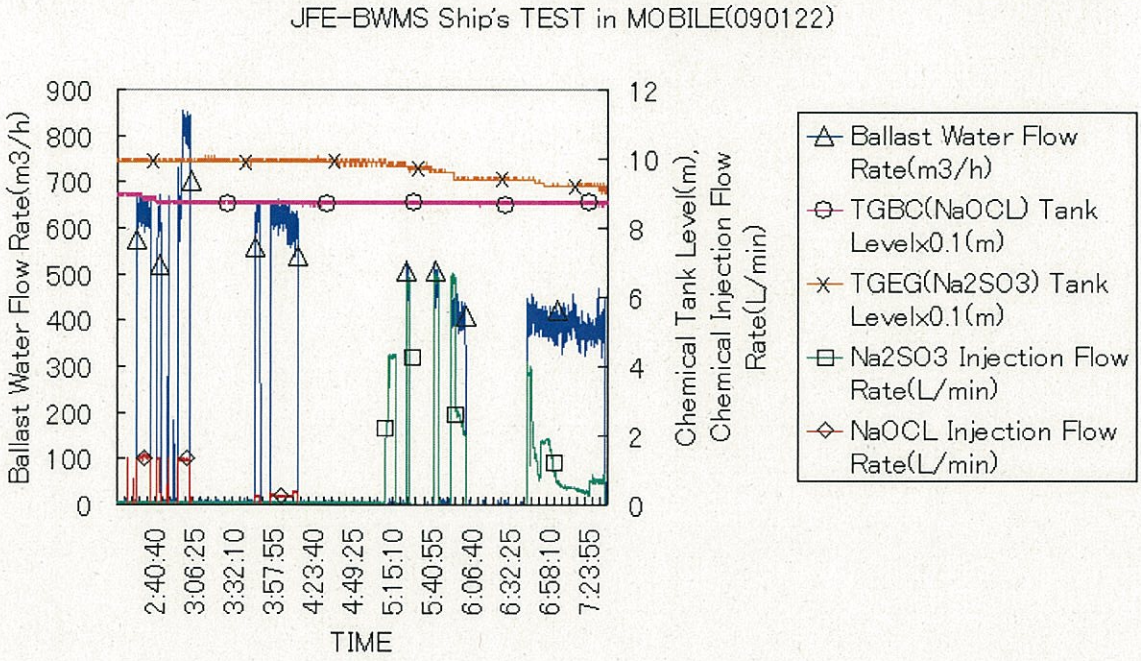
5. Impremention condition of whole onboard tests

1) Chemical supply to JFE-BWMS

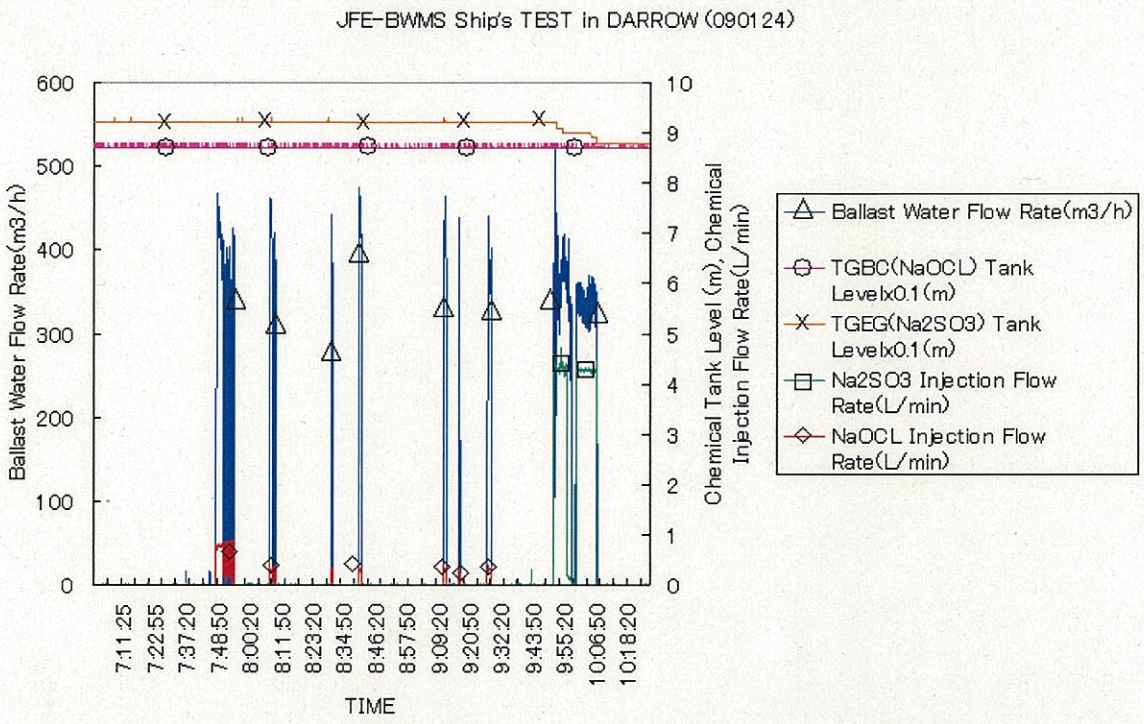
Chemicals were supplied on 3: 38, 21(Japan local time) st, Jan. 2009 at Mobile, USA.
About 1.8 L of TG ballastcleanner (TGBC) was transferred to TGBC tank.
About 2.3 L of TG Environmental Guard (TGEG) was transferred to TGEG tank.



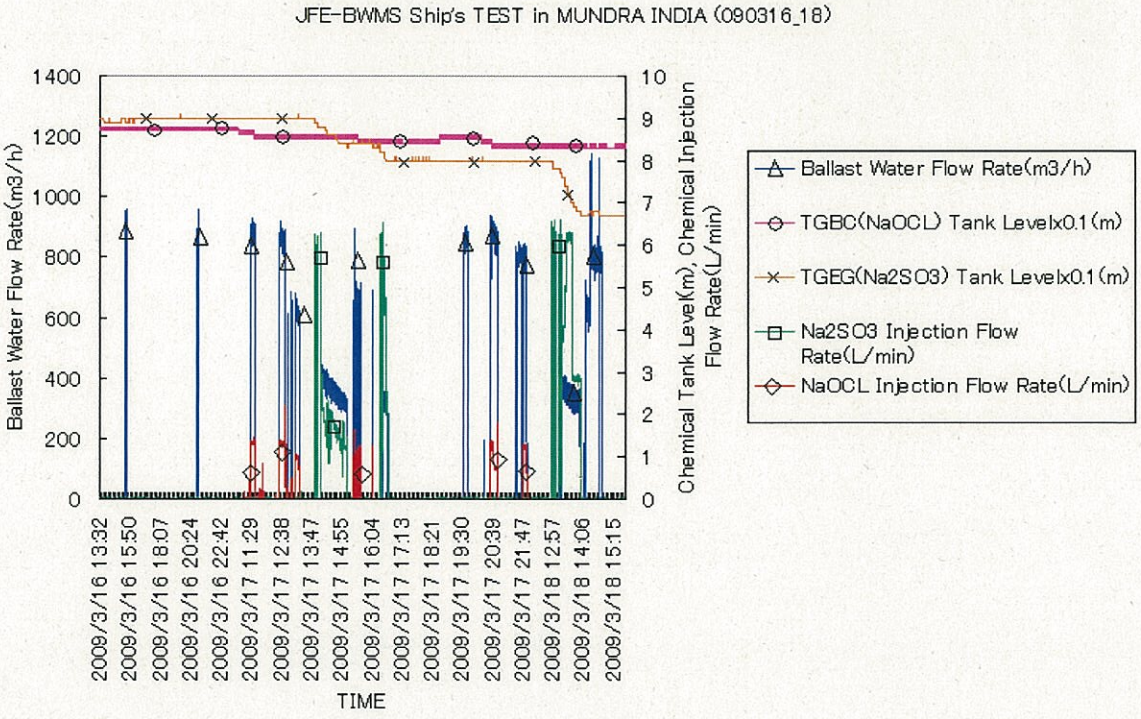
2) 22nd Jan. 2009, 14:00～(Japan Time) Uptaking &Discharge tests. at Mobile



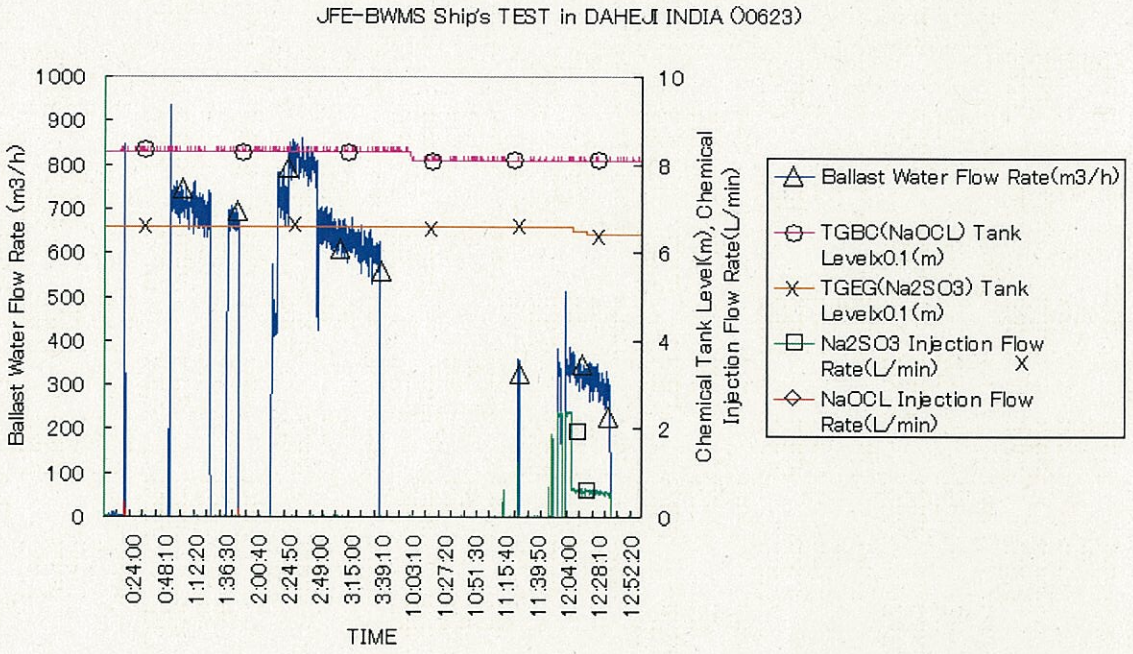
3) 24th Jan. 2009 7:45～(Japan Time) Uptaking &Discharge tests at Darrow



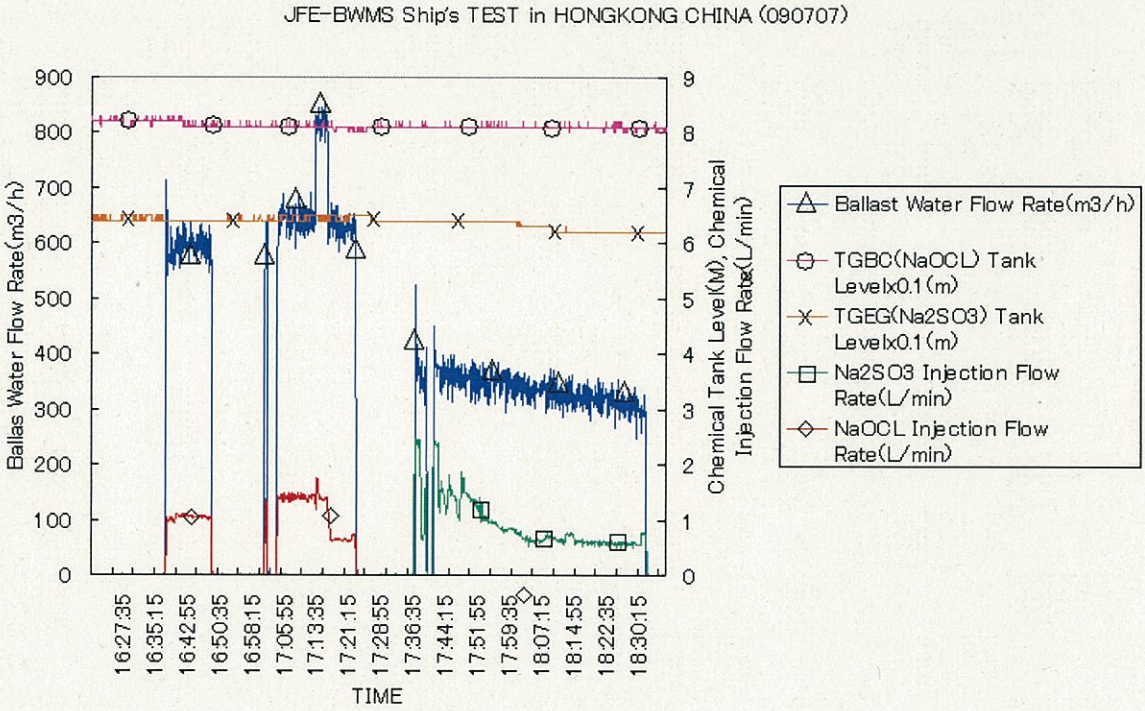
4) 16th March 2009～18th March 16, 16:00～18:00(Japan Time) Uptaking & Discharge at MUNDRA



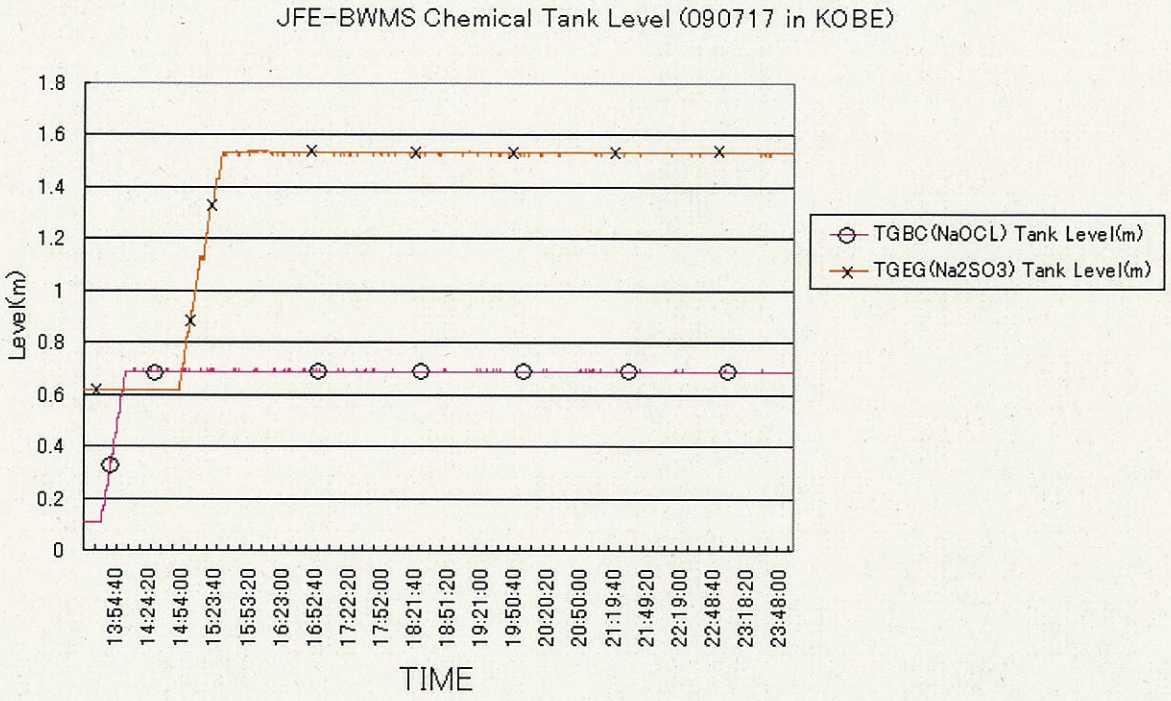
5) 23rd Jun. 2009　0:00～(Japan time)　Uptaking & Discharge Tests　　At DAHEJI



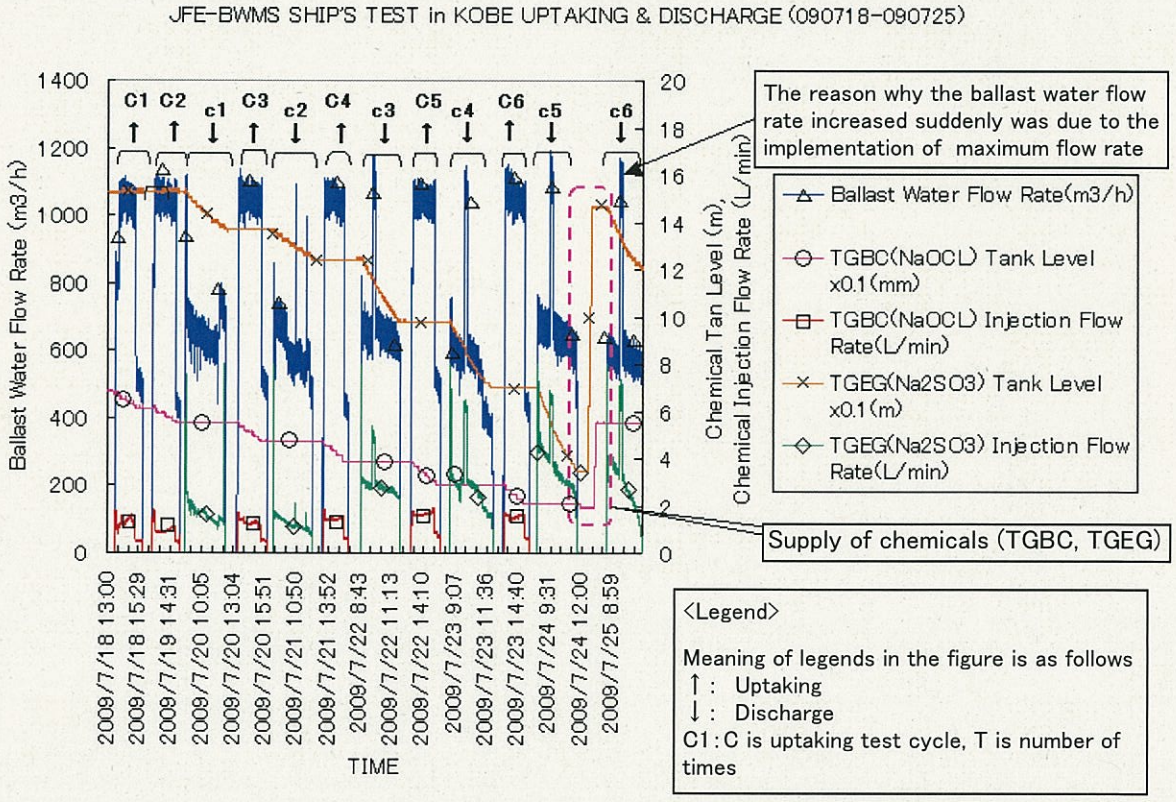
6) 7th Jul. 2009　11　Uptaking &Discharge tests　　at HONGKONG



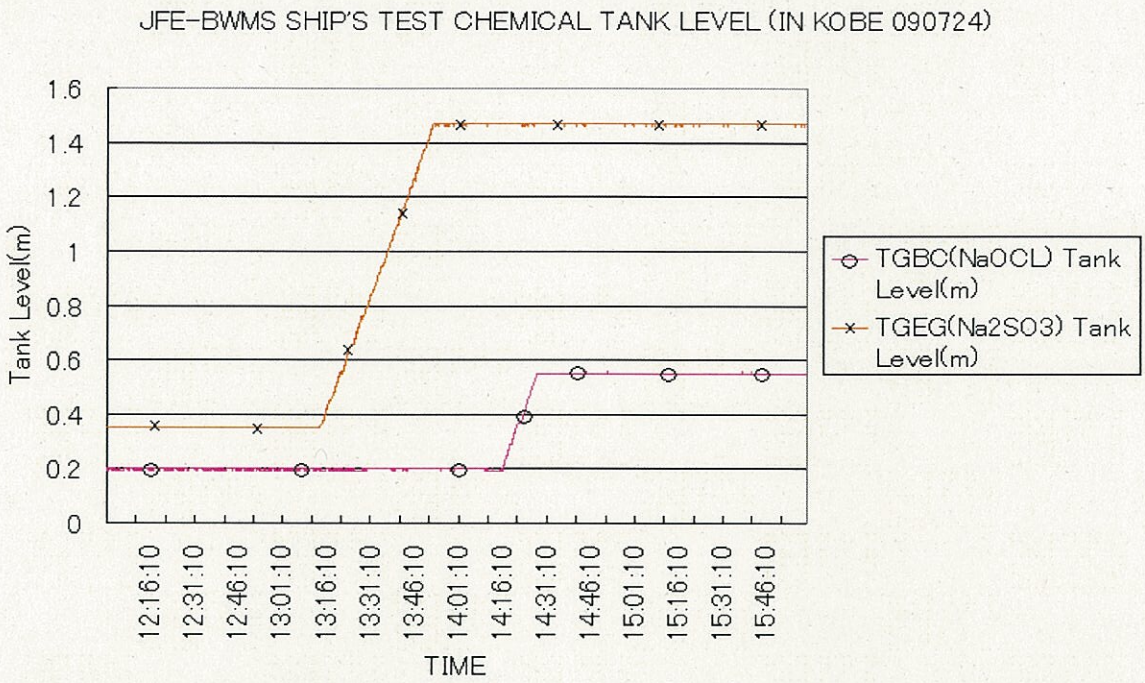
7) 17th Jul. 2009 13:40 Chemical supply at Kobe.
1.2m3 of TG Ballastcleaner (TGBC) was supplied into TGBC tank with 1.2m3 capacity.
1.8m3 of TG Environmentalguard (TGEG) was supplied into TGEG tank



8) 18th Jul. 2009, 13:00 ～ 25th (Japan time) Uptaking &Discharge test at KOBE



9) 24th Jul. 2009 13:00 chemicals were additionally supplied at Kobe
0.7m3 of TG Ballastcleaner (TGBC) was supplied into TGBC Tank
2.2m3 of TG Environmentalguard (TGEG) was supplied into TGBC tank



JFE BWMS "SAGA PIONEER" Onboard test

Master schedule (Plan)

JFE Engineering Corporation
Ship Machinery Div. BWMS Dept.
Planned on 25th Dec. 2008

Item \ Year & Day	October 2008	November	December	January 2009	February	March	April	May	June	July
	10 20	10 20 30	10 20 30	10 20 30	10 20 30	10 20 30	10 20 30	10 20 30	10 20 30	10 20 30
0. Original Schedule	Granted for Basic Approval	Onboard tests		(NIVA Norway)						
1. Movement of the ship										
Rotterdam(Hol)										
Antwarp(Hol)										
Vissingen(Hol)										
Portocel(Bra)										
Mobile(Alabama USA)										
Darrow(Louisiana USA)										
Far East					回航?					
2. Relation to the onboard tests										
Preparation				Shipping of chemicals & equipments for additional tests・Chemical tests						
				Onboard preparation tests (Uptaking)						
				Set Up of onsite laboratory, procurance of chemicals & additional test						
					Onboard tests (Discharge)					
Voluntary Tests					Shipping of chemicals & equipments for additional tests					
					Voyage with ballast	Voluntary Tests (1st)				
					Ballast discharge tests					
						Loaded Voyage				
						Voluntary Tests (2nd)				
Onboard Tests						Main tests (1st)				
						Main tests (2nd)				
						Main tests (3rd)				
							Main tests (preliminary)			
							Main tests (preliminary)			
							BWMS Onboard Test Duration (6 month)			
4. Note										

Annex—6 Results of Preliminary Inspections before Onboard Test

B. Electrical

Ballast Water Management System

Onboard Test Procedure

1. Wiring Check

2. Insulation Resistance Measurement Test

3. Grounding Check

4. Auxiliary Equipment Operation Confirmation Test

5. Instrumentation Calibration Test: Seawater Flow Meters, Chemical Injection Flow Meters, and Residual Chlorine Meters

6. Sequence Test (Operation Monitoring Operation, Alarm Tests, Protective Interlock Test)

7. Interlock Test (Water Test)

8. Interlock Test (Chemical Agent Test): Marine Test

1. Wiring Check

(1) Purpose

To confirm that electrical and instrumentation equipment in the Ballast Water Management System (BWMS) which is the object of inspection is correctly wired.

(2) Inspection Method

Confirm that the wiring of the BWMS which is the object of inspection is as shown in the connection diagrams (schematics) prepared by Ohshima Shipbuilding Co., Ltd. and JFE Engineering Corporation.

(3) Judgment criteria

Shall be wired as shown in the connection diagrams.

2. Insulation Resistance Measurement Test

(1) Purpose

To confirm whether the insulation conditions of the electrical equipments and electrical circuits of the BWMS, which is the object of inspection, are acceptable or not.

(2) Inspection Method

Measure the insulation resistance between conducting parts and ground using a DC 500 V insulation resistance tester.

The objects of measurement are power supply cables of boards and equipment, and power supply cables of electric motors and motor-driven valves.

(3) Judgment criteria

Shall be $\geqq 100$ MΩ.

3. Grounding Check

(1) Purpose

To confirm that the grounds of electrical and instrumentation equipment of the BWMS which is the object of inspection are connected to the ship's hull (common steel plate).

(2) Inspection Method

Measure the tester resistance ranges of the ground terminals of boards and equipment and part of the steel plates of the ship's hull.

(3) Judgment criteria

Confirm that the terminals of panels and equipment and the steel plates of the ship's hull are completely connected.

4. Auxiliary Equipment Operation Confirmation Test

(1) Purpose

To confirm that the direction of rotation and current values of electric motors of the BWMS, which is the object of inspection, are normal.

(2) Inspection Method

Measure the direction of rotation and the current value of the electric motors concerned. Current values shall be measured under load operation. Voltage shall also be measured at the same time.

(3) Judgment Criteria

The direction of rotation shall agree with the rotation marking, and the current value shall be the rated current or less.

5. Instrumentation Calibration Test

(1) Purpose

To confirm that the seawater flow meters, chemical injection flow meters, and residual chlorine meters of the BWMS which is the object of inspection give correct readings.

(2) Inspection Method

① Seawater Flow Meters

- In a condition in which chemical agents are not injected, start the ballast pump and perform either injection of water into the ballast tank or discharge from the ballast tank, measure the amount of increase (or decrease) in the tank and the time. Using these measurement results, calculate the seawater flow rate, and compare the result with the reading of the seawater flow meter.

② Chemical Injection Flow Meters

Fill the chemical tank with tap water, start the chemical injection pump, and measure the amount of decrease in the tank and time. Using the measurement results, calculate the chemical injection rate, and compare the result with the reading of the chemical injection flow meter.

③ Residual Chlorine Meters

- Connect the electrode of the residual chlorine meter to the electrode tank of the simple tank unit.

- Inject the equivalent of 10 ppm of sodium hypochlorite into the pump unit for 0-30 mg/L residual chlorine meter.

Measure the water in the simple pump unit by the DPD method.
Compare the result with the reading of the residual chlorine meter.

- Inject the equivalent of 2 mg/L of sodium hypochlorite into the pump unit for 0.2-3 mg/L residual chlorine meter.

Measure the water in the simple pump unit by the DPD method.
Compare the result with the reading of the residual chlorine meter.
Also confirm 0 mg/L using water without injection of sodium hypochlorite.

(3) Judgment Criteria

The results shall be within the range of allowable error for each instrument:

① Seawater flow meter: ±5% (value of rated value)

② Chemical injection flow meter: ±5% (value of rated value)

③ Residual chlorine meter: ±5% (value of rated value)

6. Sequence Test (Operation Monitoring Operation, Alarm Tests, Protective Interlock Test)

(1) Purpose

To confirm that the BWMS which is the object of inspection operates normally, and display devices, alarm devices, and protective devices operate normally.

(2) Inspection Method

① With the ballast pump in a stopped condition, input a simulation signal that the ballast pump is in operation.

Short-circuit the signal wire using the control panel outside wire terminal.

② Fill the chemical tank with tap water.

③ Start the sodium hypochlorite pump by operating the ballast water injection switch, and confirm by the electromagnetic flow meter that water is being injected.

④ Confirm that the BWMS stops normally by operating the ballast water stop switch.

⑤ Start the sodium hypochlorite pump by operating the ballast water discharge switch, and confirm by the electromagnetic flow meter that water is being discharged.

⑥ Confirm that the BWMS stops normally by operating the ballast water stop switch.

⑦ Confirm alarm displays, valve closing operation, and pump stop on the ballast water control panel and the ballast water operation panel using simulated signals.

⑧ Perform ballast booster pump stop operation, and confirm operation stop and abnormal signals. However, this operation is performed in an MCCB cut condition so that the pump is not started.

(3) Judgment Criteria

① Confirm operation/stop of ballast water injection/discharge operate normally in accordance with the operation stop interlock diagram.

② Confirm proper display of alarms in accordance with the protective interlock diagram.

7. Interlock Test (Water Test)

(1) Purpose

To confirm normal operation of the BWMS which is the object of inspection under a condition without injection of chemical agents.

(2) Inspection Method

① Fill the chemical agent tanks with tap water.

② Start the ballast pump.

③ Confirm that sodium hypochlorite (water) is injected and ballast water of the target residual chlorine concentration (simulated input) is injected by operating the ballast water injection switch.

④ Collect the ballast water in the ballast tank.

⑤ Start the ballast booster pump.

⑥ Stop the ballast booster pump.

⑦ Confirm that the BWMS stops normally by operating the ballast water stop switch.

⑧ While discharging the ballast water from the tank by operating the ballast water discharge switch, measure the residual chlorine content, inject sodium sulfite corresponding to that residual chlorine concentration (simulated value), and discharge the ballast water overboard.

⑨ Confirm that the BWMS stops normally by operating the ballast water stop switch.

(3) Judgment Criteria

Confirm that operation/stop of ballast water injection/discharge operate normally in accordance with the operation stop interlock diagram.

8. Interlock Test (Chemical Agent Test)

(1) Purpose

To confirm that the BWMS which is the object of inspection operates normally.

(2) Inspection Method

⑨ Fill the chemical agent tanks with sodium hypochlorite and sodium sulfite.

⑩ Start the ballast pump.

⑪ Confirm that sodium hypochlorite is injected and the target residual chlorine is injected into ballast water by operating the injection switch.

⑫ Collect the ballast water in the ballast tank.

⑬ Start the ballast booster pump.

⑭ Stop the ballast booster pump.

⑮ Confirm that the BWMS stops normally by operating the ballast water stop switch. While injecting ballast water from the tank by operating the ballast water discharge switch, measure the residual chlorine concentration. Inject sodium sulfite corresponding to that residual chlorine concentration, and discharge the ballast water overboard.

⑯ Confirm that the BWMS stops normally by operation of the ballast water stop switch.

(3) Judgment criteria

Confirm that operation/stop of ballast water injection/discharge operate normally in accordance with the operation stop interlock diagram.

Test Results

1. Wiring Check

2. Insulation Resistance Measurement Test

3. Grounding Check

4. Auxiliary Equipment Operation Confirmation Test
5. Instrumentation Calibration Test: Seawater Flow Meters, Chemical Injection Flow Meters, Residual Chlorine Meters

6. Sequence Test (Operation Monitoring Operation, Alarm Tests, Protective Interlock Test)

7. Interlock Test (Water Test)

8. Interlock Test (Chemical Agent Test): Marine Test

1. Wiring Check

Checked by: Aoki

No.	Equipment name	—	Equipment name	Date	Result
1	BWMS MOTOR PANEL		Filter Motor	6/30	OK
2	BWMS MOTOR PANEL		NaClO injection pump	6/30	OK
3	BWMS MOTOR PANEL		Na_2SO_3 injection pump	6/30	OK
4	BWMS MOTOR PANEL		Sampling pump for treated water	6/30	OK
5	BWMS MOTOR PANEL		Sampling pump for Ball. Pump Suc.	6/30	OK
6	BWMS MOTOR PANEL		Ballast Booster Pump inlet valve	6/30	OK
7	BWMS MOTOR PANEL		Filter outlet valve	6/30	OK
8	BWMS MOTOR PANEL		Filter Normal Backwash valve	6/30	OK
9	BWMS MOTOR PANEL		Filter Highflow Backwash valve	6/30	OK
10	BWMS MOTOR PANEL		Filter Bypass valve	6/30	OK
11	BWMS Chemical Injection Pump Starting Panel		NaClO injection Pump	6/30	OK
12	BWMS Chemical Injection Pump Starting Panel		Na_2SO_3 injection Pump	6/30	OK
13	BWMS Control Panel		Sea Water Flow	6/30	OK
14	BWMS Control Panel		NaClO injection Flow	6/30	OK
15	BWMS Control Panel		Na_2SO_3 injection Flow	6/30	OK
16	BWMS Control Panel		Residual Chlorine Meter (For NaClO control) 0-30 ppm	6/30	OK
17	BWMS Control Panel		Residual Chlorine Meter (For Na_2SO_3 control) 0-30 ppm	6/30	OK

18	BWMS Control Panel		Residual Chlorine Meter (For Supervision of discharge) 0-3 ppm	6/30	OK
19	BWMS Control Panel		ORP meter	6/30	OK
20	BWMS Control Panel		Press. Transmitter for Ballast Booster Pump Suc.	6/30	OK
21	BWMS Control Panel		Press. Transmitter for Ballast Booster Pump del.	6/30	OK
22	BWMS Control Panel		Press. Transmitter for Venturi inlet	6/30	OK
23	BWMS Control Panel		Press. Transmitter for Venturi outlet	6/30	OK
24	BWMS Control Panel		Press. Transmitter for Filter inlet	6/30	OK
25	BWMS Control Panel		Press. Transmitter for Filter outlet	6/30	OK
26	BWMS Control Panel		Diff. Press. Transmitter for Filter	6/30	OK
27	BWMS Control Panel		Diff. Press. Switch for Filter	6/30	OK
28	Chemical Tank Level meter Box		NaClO storage Tank Level Transmitter	6/30	OK
29	Chemical Tank Level meter Box		Na_2SO_3 storage Tank Level Transmitter	6/30	OK
30	BWMS Control Panel		Chemical Tank Level meter Box	6/30	OK
31	BWMS Control Panel		Chemical Tank Level Alarm Box	6/30	OK
32	BWMS Control Panel		BWMS Motor Panel	6/30	OK
33	BWMS Control Panel		BWMS Operation Panel	6/30	OK
34	BWMS Control Panel		Ballast Pump Starting Panel	6/30	OK
35	BWMS Control Panel		Ballast Booster Pump Starting Panel	6/30	OK

2. Insulation Resistance Measurement Test

Measured by: Aoki

No.	Equipment name	Measurement point	Insulation resistance (MΩ)	Date	Result
1	BWMS Control Panel	Primary power supply - E	100 MΩ or more	6/30	OK
2	BWMS Motor Panel	Primary power supply - E	100 MΩ or more	6/30	OK
3	BWMS Operation Panel	Primary power supply - E	100 MΩ or more	6/30	OK
4	BWMS Chemical Injection Pump Starting Panel	Primary power supply - E	100 MΩ or more	6/30	OK
5	Chemical Tank Level meter Box	Primary power supply - E	100 MΩ or more	6/30	OK
6	Chemical Tank Level Alarm Box	Primary power supply - E	100 MΩ or more	6/30	OK
7	Filter Motor	Coil – E	100 MΩ or more	6/30	OK
8	NaClO injection pump	Coil – E	100 MΩ or more	6/30	OK
9	Na_2SO_3 injection pump	Coil – E	100 MΩ or more	6/30	OK
10	Sampling pump for treated water	Coil – E	100 MΩ or more	6/30	OK
11	Sampling pump for Ball. Pump Suc.	Coil – E	100 MΩ or more	6/30	OK

Judgment criteria: 100 MΩ or more

3. Grounding Check

Measured by: Aoki

No.	Equipment name	Measurement point	Connection	Date	Result
1	BWMS Control Panel	E – Hull plate	Common	6/30	OK
2	BWMS Motor Panel	E – Hull plate	Common	6/30	OK
3	BWMS Operation Panel	E – Hull plate	Common	6/30	OK
4	BWMS Chemical Injection Pump Starting Panel	E – Hull plate	Common	6/30	OK
5	Chemical Tank Level meter Box	E – Hull plate	Common	6/30	OK
6	Chemical Tank Level Alarm Box	E – Hull plate	Common	6/30	OK
7	Filter Motor	E – Hull plate	Common	6/30	OK
8	NaClO injection pump	E – Hull plate	Common	6/30	OK
9	Na_2SO_3 injection pump	E – Hull plate	Common	6/30	OK
10	Sampling pump for treated water	E – Hull plate	Common	6/30	OK
11	Sampling pump for Ball. Pump Suc.	E – Hull plate	Common	6/30	OK
12	Ballast Booster Pump inlet valve	E – Hull plate	Common	6/30	OK
13	Filter outlet valve	E – Hull plate	Common	6/30	OK
14	Filter Normal Backwash valve	E – Hull plate	Common	6/30	OK
15	Filter Highflow Backwash valve	E – Hull plate	Common	6/30	OK
16	Filter Bypass valve	E – Hull plate	Common	6/30	OK
17	NaClO injection Pump	E – Hull plate	Common	6/30	OK
18	Na_2SO_3 injection Pump	E – Hull plate	Common	6/30	OK
19	Sea Water Flow	E – Hull plate	Common	6/30	OK
20	NaClO injection Flow	E – Hull plate	Common	6/30	OK
21	Na_2SO_3 injection Flow	E – Hull plate	Common	6/30	OK
22	Residual Chlorine Meter (For NaClO control) 0-30 ppm	E – Hull plate	Common	6/30	OK
23	Residual Chlorine Meter (For Na_2SO_3 control) 0-30 ppm	E – Hull plate	Common	6/30	OK
24	Residual Chlorine Meter (For Supervision of discharge) 0-3	E – Hull plate	Common	6/30	OK

	ppm				
25	ORP meter	E – Hull plate	Common	6/30	OK
26	Press. Transmitter for Ballast Booster Pump suc.	E – Hull plate	Common	6/30	OK
27	Press. Transmitter for Ballast Booster Pump del.	E – Hull plate	Common	6/30	OK
28	Press. Transmitter for Venturi inlet	E – Hull plate	Common	6/30	OK
29	Press. Transmitter for Venturi outlet	E – Hull plate	Common	6/30	OK
30	Press. Transmitter for Filter inlet	E – Hull plate	Common	6/30	OK
31	Press. Transmitter for Filter outlet	E – Hull plate	Common	6/30	OK
32	Diff. Press. Transmitter for Filter	E – Hull plate	Common	6/30	OK
33	Diff. Press. Switch for Filter	E – Hull plate	Common	6/30	OK
34	NaClO storage Tank Level Transmitter	E – Hull plate	Common	6/30	OK
35	Na_2SO_3 storage Tank Level Transmitter	E – Hull plate	Common	6/30	OK

4. Auxiliary Equipment Operation Confirmation Test

Measured by: Aoki

No.	Equipment name	Rotation direction	Current value (A)	Date	Result
1	Filter Motor	Clockwise	0.2	7/1, 31	OK
2	NaClO injection pump	Clockwise	0.64/100%	7/1, 31	OK
3	Na_2SO_3 injection pump	Clockwise	0.64/100%	7/1, 31	OK
4	Sampling pump for treated water	Clockwise	0.7	7/1, 31	OK
5	Sampling pump for Ball. Pump Suc.	Clockwise	0.7	7/1, 31	OK
6	Ballast Booster Pump inlet valve	Both directions	2.6	7/1, 31	OK
7	Filter outlet valve	Both directions	2.2	7/1, 31	OK
8	Filter Normal Backwash valve	Both directions	0.7	7/1, 31	OK
9	Filter Highflow Backwash valve	Both directions	0.7	7/1, 31	OK
10	Filter Bypass valve	Both directions	2.1	7/1, 31	OK

5. Instrumentation Calibration Test: Seawater Flow Meters, Chemical Flow Meters, and Residual Chlorine Meters

Measured by: Kataoka, Aoki, Maeda

(1) Seawater Flow Meters

No.	Flow meter reading (m^3/h)	Ballast tank level (m^3)	Time (sec)	Value of flow rate converted from tank level (m^3/h)	Date	Result
1	—	—	17:19:57	—	7/16	OK
2	—	—	17:24:57	385.1		
3	—	—	17:29:57	367.2		
4	—	—	17:34:57	379.2		
Average	395.4			377.2		

(2) NaClO Flow Meters

No.	Flow meter reading (L/min)	NaClO tank level(L)	Time (sec)	Value of flow rate converted from tank level (L/min)	Date	Result
	—		—	—	7/18	OK
1	—		9:10:00			
2	—		9:40:00			
	—					
Average	2.097	119. 8	30	1.997		

(3) Na_2SO_3 Flow Meters

No.	Flow meter reading (L/min)	Na_2SO_3 tank level (L)	Time (sec)	Value of flow rate converted from tank level (L/min)	Date	Result
	—		—	—	7/31	OK
1	—	2,179.4(1.0897 m)	16:18:25			

2	—	2,159(1.0795 m)	16:28:25			
	—					
Average	1.995	20.4	10	2.04		

(4) Residual Chlorine Meters

	Application	Standard Cl residual chlorine concentration for calibration (ppm)	Reading of residual chlorine meter (ppm)	DPD (ppm)	Date	Result
1	For NaClO control 0-30 ppm	10	10.2	9.6	7/15	OK
2	For Na_2SO_3 control 0-30 ppm	10	11	10.2	7/15	OK
3	For Supervision of discharge-0.2-3 ppm	0	0 2.44	0 2.3	7/15	OK

6. Sequence Test

(1) Operation Monitoring

Test date: July 1, 2008

Test performed by: Aoki, Aiba

No.	Equipment name	Start operation	Stop operation	Control panel display	Operation panel display	Result
1	Filter Motor	○	○	○	○	OK
2	NaClO injection pump	○	○	○	○	OK
3	Na_2SO_3 injection pump	○	○	○	○	OK
4	Sampling pump for treated water	○	○	○	○	OK
5	Sampling pump for Ball. Pump Suc	○	○	○	○	OK
No.	Equipment name	Opening operation	Closing operation	Control panel display	Operation panel display	Result
6	Ballast Booster Pump inlet valve	○	○	○	○	OK
7	Filter outlet valve	○	○	○	○	OK
8	Filter Normal Backwash valve	○	○	○	○	OK
9	Filter Highflow Backwash valve	○	○	○	○	OK
10	Filter Bypass valve	○	○	○	○	OK

(2) Alarm Test/Protective Interlock Test

Test date: July 2, 2008

Test performed by: Aoki, Aiba

No.	Alarm name	Control panel/Display	Operation panel/Display	BWMS Stop	Result
1	BALLAST BOOSTER PUMP FAULT	○	○	④	OK
2	FILTER BYPASS VALVE FAULT	○	○	③,④	OK
3	NaClO PUMP FAULT	○	○	①,②,④	OK
4	NaClO STORAGE TANK LEVEL LOW	○	○	①,②,④	OK
5	Na_2SO_3 PUMP FAULT	○	○	③,④	OK
6	BOOSTER PUMP INLET VALVE FAULT	○	○	①,②,④	OK
7	FILTER OUTLET VALVE FALUT	○	○	①,②,④	OK
8	NORMAL BACKWASH VALVE FAULT	○	○	①,②,④	OK
9	HIGHFLOW BACKWASH VALVE FAULT	○	○	①,②,④	OK
10	BALLAST PUMP FAULT	○	○	①,②,③ ④	OK
11	FLOW METER FAULT	○	○	①,②,③ ④	OK
12	NaClO INJECTION CONTROL ABNORMAL	○	○	①,②,④	OK
13	Na_2SO_3 INJECTION CONTROL ABNORMAL	○	○	③,④	OK
14	Na_2SO_3 STORAGE TANK LEVEL LOW	○	○	③,④	OK
15	DELIVERY PRESS. OF BBP LOW	○	○	①,②,③ ④	OK
16	UPTAKE.WATER R.CL.	○	○	①,②	OK

	ABNORMAL				
17	NaClO INJECTION FLOW ABNORMAL	○	○	①,②	OK
18	PLC ABNORMAL	○	○	None	OK
19	BALLAST WATER FLOW LOW	○	○	①,②,③ ④	OK
20	SEA WATER FLOW FAULT	○	○	①,②,③ ④	OK
21	ORP FAULT	○	○	None	OK
22	NaClO INJECTION FLOW HIGH LIMIT	○	○	①,②,④	OK
23	R.CL. FAULT(DISCHARGE)	○	○	③,④	OK
24	R.CL. FAULT(UPTAKING)	○	○	①,②,④	OK
25	DISCH. WATER R.CL. ABNORMAL	○	○	③,④	OK
26	FILTER FAULT	○	○	①,②,④	OK
27	EMERGENCY STOP	○	○	①,②,③ ④	OK
28	INLET PRESS. OF FILTER LOW	○	○	None	OK
29	BALLAST WATER FLOW LOW	○	○	None	OK
30	Na_2SO_3 INJECTION FLOW ABNORMAL	○	○	③,④	OK
31	NaClO STORAGE TANK LEVEL H	○	○	None	OK
32	Na_2SO_3 STORAGE TANK LEVEL H	○	○	None	OK
33	CONTROL FAILURE	○	○	No starting	OK
34	SAMPL.P. FOR BALL.PUMP SUC. FAULT	○	○	③,④	OK
35	NETWORK ABNORMAL	○	○	None	OK
36	DATA LOGGER ABNORMAL	○	○	None	OK
37	FILTER DIFFERENTIAL	○	○	None	OK

	PRESS. HIGH				
38	SAMPL.P. FOR TREATED WATER FAULT	○	○	①,②,③ ④	OK
39	DISCH. WATER R.CL WARNING	○	○	None	OK

<Notes>

Stopped or fully-closed equipment

① Group:FILTER

BALLAST BOOSTER PUMP INLET VALVE

FILTER OUTLET VALVE

FILTER NORMAL BACKWASH VALVE

FILTER HIGH FLOW BACKWASH VALVE

② Group: SAMPLING PUMP FOR TREATED WATER

NaClO INJECTION PUMP

③ Group: SAMPLING PUMP FOR TREATED WATER

SAMPLING PUMP FOR BALL. PUMP SUC.

Na_2SO_3 INJECTION PUMP

FILTER BYPASS VALVE

④ Group: BALLAST BOOSTER PUMP

7. Interlock Test (Water Test)

Test date: July 18, 2008

Test performed by: Kataoka, Aoki, Maeda, Aiba

1) Interlock Tests

July 18, 2008, 9:00-12:15 Sodium hypochlorite control (simulated)

|

July 31, 2008, 12:15 - 16:12 Sodium sulfite control (simulated)

2) Trend Record

See Annex – 1.

ANNEX-7 Bioanalytical Results of Onboard Tests using JFE-BWMS

Contents

1. Abstract

Onboard tests using SAGA PIONEER equipped with JFE-BWMS were conducted for continuous 6 test cycles at a quay of Rokko Island in Port of Kobe from July 18th to July 25th, 2009. All test cycles fulfilled the requirements specified in G8 guideline and were "Effective Test Cycle". As all measurement results for each test cycle met the regulation D-2, it was evaluated that JFE-BWMS met regulation D-2 of BWM Convension with 6 continuous test cycles of onboard tests.

JFE-BWMS was installed in the 47,000 DWT Type Bulk Carrier "SAGA Pioneer" and the test water sampling, concentration and bioanalytical measurements were performed using test water taken from the sampling water outlet of two systems, which consist of pre-treatment water, treated water and control water, and lead to 1 m^3 capacity tanks prepared on the mooring quay. But the sample water for bacteria analysis was collected in the engine room to prevent contamination. Except for the water quality terms measured directly at site, conservations and measurements were performed in the onsite labolatory which was set up at 50m distance from mooring quay.

These onboard tests were performed based on the standard methods specified in "Bioanalytical Methods for the Approval of Ballast Water Management Systems (Revised Edition)" proposed by the Ship Equipment Inspection Society of Japan.

2. Test items and Requirements

2.1 Requirements

2.1.1 Regulation D-2

Regulation D-2 *Ballast Water Performance Standard* consisted of D-2.1 and D-2.2 as follows.

D-2.1 Ships conducting Ballast Water Management in accordance with this regulation shall discharge less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension and less than 10 viable organisms per millilitre less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension; and discharge of the indicator microbes shall not exceed the specified concentrations described in paragraph 2.

D-2.2 Indicator microbes, as a human health standard, shall include:

.1 Toxicogenic *Vibrio cholerae* (O1 and O139) with less than 1 colony forming unit (cfu) per 100 millilitres or less than 1 cfu per 1 gram (wet weight) zooplankton samples ;

.2 *Escherichia Coli.* less than 250 cfu per 100 millilitres;

.3 Intestinal Enterococci less than 100 cfu per 100 milliliters.

2.1.2 Requirements for onboard tests

As following requirements were shown for onboard tests, all measurements were performed to meet these requirements during each test cycle.

(1) Test Cycle

Tests shall be performed at normal flow rate and normal ballast capacity of the test ship. Each test cycle should consist of the consecutive works of ballast water uptake, storage and discharge.

(2) Effectiveness standards of the test

Tests of each test cycle are judged as "Effective" only in the case where the density of aquatic organisms during uptake exceed more than 10 times of regulation D-2.1 and the density of aquatic organisms in non-treated ballast tank (called as control tank hereinafter) exceed more than regulation D-2.1.

(3) Standards for approval

BWMS shall be approved only in the case where the density of aquatic organisms in treated ballast water at discharge meets regulation D-2 in three consecutive effective test cycles.

(4) Number of samples

Number of the samples required for the performance evaluation is 3 (beginning, middle and end) for control tank during uptake and discharge, 9 (beginning 3 samples, middle 3 samples and end 3 samples) for treated ballast water during discharge.

(5) Sample volume etc.

Sample volume is at least $1m^3$ for large size group aquatic organisms, at least 1L for small size group aquatic organisms and at least 500mL for bacteria. In concentrating L size group and S size group organisms, net with mesh size of less than 50μm and 10μm in diagonal line should be used respectively.

(6) Measuring items for water quality

In respect of measuring items for water quality, measurements of salinity, particulate organic carbon (POC hereinafter), total suspended solids (TSS hereinafter) are required.

2.2 Test items

Measured items during onboard tests are shown in Table-1 including above stated regulation D-2 requirements.

Table-1 Measured items during onboard tests

Classification	Measured Items	Point of measurement and sampling	Measuring Method
Aquatic organisms	L size group	Sampled and concentrated at quay	Speculum by microscope
	S size group	Sampled at quay	Speculum by microscope
Bacteria	Toxicogenic *Vibrio Cholerae* (O1 and O139)	Sampled in engine room	Spread plate method
	Escherichia Coli.	ditto	ditto
	Enterococci	ditto	ditto

	Heterotorophic bacteria	ditto	ditto
Water Quality	Temperature	Measured at quay	Direct measurement by water quality meter
	Salinity	ditto	ditto
	TSS	Sampled at quay	Water sampling and analysis
	POC	ditto	Water sampling and analysis
	Turbidity	Measured at quay	Direct measurement by water quality meter
	pH	ditto	ditto
	Dissolved Oxgen (DO)	ditto	ditto

Test water was sampled, measured and treated with concentration, microscopic observation during these onboard tests.

In these onboard tests, it became possible to sample and concentrate the control and treated ballast water at the quay, because test ship, "Bulk carrier, SAGA Pioneer", equipped with JFE-BWMS was layed up at the quay. Therefore, works for obtaining test water and sampling for bacteria analysis were performed on board and other works for obtaining test water, measurements, concentration and counting were performed at the facilities which were set-up on the quay (i.e., $1m^3$ capacity tanks and onsite laboratory).

Hence, the works relating bioanalytical evaluation of organisms and measurements of water quality became as follows.

a. Engine Room — Valve operations for control and treated ballast water intake
Sampling of test water for bacteria analysis

b. Attachment Room — Filling test water into $1m^3$ tank and re-transfer work using underwater pump (Pump was stopped after siphonic condition)

c. Quay (Tank side) — Filling test water into $1m^3$ tank and concentration of L size sample
Sampling of test water for S size organisms and water quality measurements, cleaning of tanks

d. Quay (Onsite Laboratory)
Re-concetration and speculum by microscope for L size organisms
Concetration and speculum by microscope for S size organisms
Spread, incubation and measurement of bacteria
Filtration and desiccation for TSS measurement

Sampling valves, hoses and tanks relating to uptake water, control water and treated water were set up as separated system in order to prevent cross contamination, and operated carefully not to contact each other.

< Photographs >

Photo 1 : Test Ship and water collecting tanks and measuring facility

Test Ship “SAGA PIONEER” and test water collecting tanks and measuring facility (Front side tents)

Photo 2 : Outside view of onsite laboratory

50m distance from the test ship

Photo 3 : Facility for water sampling and measurements

Tanks with 1m3 capacity for concentration of L size rganisms

Photo 4: Water sampling for bacteria analysis

Water sampling for bacteria analysis
(in Engine Room)

Photo 5: 1m3 capacity tank in attachment room

1m3 capacity tank in attachment room
(Temporary storage of test water from engine room. This water is lead to 1m3 tank on the quay.)

Photo 6: Set up of the net for concentration of L size organisms

Net with 30cm diameter, 35μm mesh was set on the top of $1m^3$ tank.

Photo 7: Water quality meter
(direct reading type)

Water quality measuring sensor
(temperature, salinity, DO etc.)

Photo 8: Speculum by microscope L
size organisms

Concentrated test water sample was
transfered to petri dish and visualized by
stereomicroscope

3. Test Methods

3.1 Aquatic organisms

3.1.1 L size group organisms

(1) Summary

Countings for L size group were performed on the samples defined in G8 guideline. Concentration was performed using 35μm mesh size hand net and filter with the same mesh size. Measurement was done confirming the minimum dimension using stereomicroscope. In these onboard tests, 1 m^3 test water was concentrated and L size organisms were enumerated in accordance with G8 guideline.

(2) Concentration

1m^3 test water samples were collected and concentrated simultaneously for uptake water during uptake, treated water and control water during discharge. 1m^3 test water capacity was measured based on the scale indicated on the tank wall. However, 1,10 m^3 sampling was performed in the attachment room considering to avoid residual water in the hoses to tanks on the quay and just about 1,05 m^3 was collected in the tank on the quay subtracting test water for analysis (less than 10L in total) and water quality measurement. Therefore counted results for L size organisms were for 1.05m^3 sample water volume, but this results were regarded as for that of 1.0 m^3.

Primary Concentration was conducted at the tank side on quay. Test water led from engine room into the 1m^3 tank in attachment room through hose was led using underwater pump. Cocentration work was done at the exit of hose using hand net with 35μm mesh size and the concentrated sample water to several hundreds mL was preserved in the plastic bottle.

Secondary concentration was applied to this concentrated sample water preserved in plastic bottle into several tens mL level using filtration equipment made of PVC pipe and 35μm mesh size net. In the case of treated ballast water where high concentration rate is possible, concentration rate becomes several ten thousands. However, in the case for uptake water and control water where the density of organisms are very high, high rate concentration was not necessary and concentration rate was determined depending on the situation.

(3) Measurement

Stereomicroscope was used for the counting of L size organisms. Test water was transferred to the ruled petri dish (5mm x 5mm) using pipetter and counted for every 5mm x 5mm area. Minimum dimension was measured using the micro scale on eyepiece lens.

Number of individual was counted using couter with distinguishing species.

Judgement of life and death were done according to appearance and mobility of the individual.

Used stereomicroscopes were SZ-H type manufactured by Olympus and WILD type manufactured by Leica.

(4) Records of the measurement results

After recording the sample name, date and time of measurement, name of the person who measured, concentration condition and volume of speculum, measurement result for each sample were recorded with principal species name (or genus name), number of the organism, minimum dimension and characteristics of the sample etc.

3.1.2 S size group organisms

(1) Summary

Measurements for S size group were performed on the samples defined in G8 guideline. Concentration works were conducted in the onsite laboratory as appropriate, and if necessary, conducted to the necessary concentration level using the filter with 7μm mesh size. Measurement work were done using biological microscope. Samle water volume should be more than 1 litter according to G8 guideline, however considering the necessity of concentration, 2 litters sample volume was adopted for these measurement.

(2) Concentration

As necessity for concentration depends on the sample condition, the filter made of 7μm mesh size was used for concentration if necessary. As in the case where the test water is 2 litters, concentration into 50ml means 40th concentration, counting of 1ml of this concentrated test water means 40 ml counting.

(3) Determination

Biological microscope was used for counting. Appropriate quantities of test water was transferred onto glass slide with ruled lines using pipetter and counted. Minimum dimension was confirmed using the micro scale on the eyepiece lens.

Number of individuals was divided broadly into species and counted using counter. Judgement of dead or alive was done essentially by the mobility for the species with motion capability and by the distributions of pigment under the microscopic observation for the species with no mobility like Diatom.

Confirmation of the viability by re-cultivation was not done because this process was not practically necessary. When organisms greater than 50μm mixed in, these were not included in the measurement.

Used microscope was BX-51 type and BX-60 type of the Olympas product.

(4) Records of the measurement results

After recording the sample name, date and time of measurement, name of the person who measured, concentration condition and volume of speculum, measurement result for each sample were recorded with principal species name (or genus name), number of the organism, minimum dimension and characteristics of the sample etc.

3.2 Measurement of bacteria

For the samples specified in G8 guideline, measurements of the toxicogenic *Vibrio Cholerae*, *Escherichia Coli*, Intestinal Enterococci and Heterotropic bacteria were performed.

In order to avoid contaminations, samples were collected at the nearest sampling water valve to the BWMS in engine room. Nevertheless minimum sampling volume for bacteria analysis is specified 500ml by G8 guideline, 2 litters sample for each test was collected in these onboard tests because it might be necessary to concentrate the sample.

The spread plate method and membrane filter method were used depend on the number of

colonies to be expected. Cultivation was performed using the incubator installed in the onsite laboratory and counting of colonies was done after specified cultivation time. Dilution and concentration were done in specified method and the results were indicated as converted values in specified unit.

3.2.1 Toxicogenic *Vibrio Cholerae*

As toxicogenic *Vibrio Chlerae* (serotype O1 and O139) specified in regulation D-2 can not measured at once, number of *Vibrio* genus including *Vibrio Cholera* was counted first using TCBS culture media. After that the appeared colonies is re-cultivated using alkaline peptone water and then toxicogenic *Vibrio Cholerae* is confirmed by separating into toxinogenicity using antiserum. In these onboard tests, the first and second steps were conducted within these separated three steps operations. That is, the colonies of *Vibrio* genus appeared even in the treated water but *Vibrio cholerae* became negative in next step cultivation, therefore it was not necessary to proceed in the third step.

As to the concentration and dilution of test water samples, the spread plate method was used for the uptaken water and control water samples and the membrane filter method was used for 100ml of treated water using more than three culture medias for each sample water.

Cultivation temperature was kept at 35°C of and duration was 24 hours. Measured results were recorded in the field note and averaged values were adopted omitting the abnormal values.

3.2.2 *Escherichia Coli.*

As explained in "BIOANALYTICAL METHODS FOR THE APPROVAL OF BALLAST WATER MANAGEMENT SYSTEMS", *Escherichia Coli* is the objective of the regulation D-2, however it is allowed to measure the number of Coliform bacteria as the alternative bacteria.

In these onboard tests, Chromocult Coliform enzyme culture media, which can be used for measure both *Escherichia coli* and Coliform were used and countings were done after the 24 hours cultivation at 35°C. More than three culture medias were used under each condition.

As to the concentration and dilution of test water samples, 100 ml of both uptake, control and treated test water was filtered, spread onto the culture media and incubated.

Measured results were recorded in the field note and averaged values were adopted omitting the abnormal values.

3.2.3 Intestinal Enterococci

As to Intestinal Enterococci, *Enterococus* group can be used in place of Intestinal Enterococci, which include Intestinal Enterococci, as explained in the "Bioanalytical method" manual. However in the case when colonies of *Enterococcus* group are found in the treated water samples, it becomes necessary to cultivate these colonies and enumerate Intestinal Enterococci. As no *Enterococcus* group colony was found, i.e. 0 cfu/100ml in these onboard tests, no secondary cultivation was performed. All works were conducted in the onsite laboratory.

The spread plate method was adoptd for the measurement of *Enterococcus* group using commercially available *Enterococus* agar media and 100ml concentrated test water using membrane filter for uptake, control and treated water was measured with more than three agar medias for each sample.

Cultivation was conducted at 36°C for 48 hours and the colonies with the color from faint pink to red were confirmed as *Enterococcus* group. Results of determination were recorded on the field note for analysis for each test water sample. After eliminating abnormal value, averaged value was

adopted.

3.2.4 Heterotropic bacteria

The spread plate method was adoptd for the measurement of Heterotropic bacteria. MB2216 agar culture media was used and cultivated at 25°C for 5 days.

For uptake water and control water, 0.1 ml of dilutioned test water into 1, 10, 100, and 1,000 times were spread on the 5 culture medias, and 100 ml of treated test water was spread onto more than 3 culture media after being filtered by the membrane filter and the number of colonies were enumerated after 5 days culturing duration.

Results of determination were recorded on the field note for analysis for each test water sample. After eliminating abnormal value, averaged value was adopted.

3.3 Water quality

It is required to measure water temperature, salinity, POC and TSS in G8 guideline, but turbidity, pH, DO (Dissolved Oxygen) and in addition to these items ORP (Oxidation Reduction Potential) were performed. Measurements were done during uptake, discharge of treated water, and control water, and the direct measurement by the measuring equipment were done at the quay where the test water samples for L size and S size group were collected.

Measurering method for each item is explained below.

3.3.1 Water temperature

Water temperature was measured by direct-reading multiple water quality equipment, AAQ1183 type made by JFE-Advantech Co., Ltd (former ALEC Electronics Co., Ltd). The sensor for water temperature is thermistor and measurering range is from –5°C to 40°C, resolution is 0.001°C and accuracy is ±0.02°C.

3.3.2 Salinity

Salinity was also measured by the direct-reading multiple water quality equipment type AAQ1183, same as water temperature.

Salinity is calculated using electric conductivity and water temperature measured by electromagnetic induction cell. Measureing range is from 0 to 40PSU, resolution is 0.001PSU and accuracy is ±0.03PSU, as practical salinity.

3.3.3 Total suspended solid (TSS)

TSS was measured by sampled water analysis. Sampled test water was filterated using filter (Wattman GF-F type, pore size 0.7μm) weighed and dryed using drying oven in the onsite laboratory after removing salt by washing with purified water. Filters were put in the hermetically sealed enclosures and weighed at the main laboratory after transportation.

Used balance was Shimazu LIBROR AEU-210.

3.3.4 Particulate organic carbon (POC)

The sampled test water was transported to the environmental laboratory and POC was measured there. TOC and DOC was measured using TOC meter and POC was calculated by subtracting DOC from TOC as the analysis method of POC.

Shimazu TOC-5000A type was used as the analytical equipment and Advantec QR100 type

was used as the filter.

3.3.5 pH

pH was measured by the direct-reading multiple water quality equipment AAQ1183 type made by JFE-Advantech Co., Ltd which was used in measurements of water temperature and salinity.

pH sensor is made of glass electrode and measuring range is from 0 to 14pH, resolution is 0.01pH and accuracy is ±0.2.

3.3.6 Dissolved oxygen (DO)

DO was also measured by the same direct-reading multiple water quality equipment AAQ1183 type made by JFE-Advantech Co., Ltd.

DO sensor is made of galvanic electrode and measuring range is from 0 to 20mg/L (0-200%), resolution is 0.01mg/L (0.01%) and accuracy is ±0.2mg/L (±1%).

3.3.7 Turbidity

Turbidity was also measured by the same direct-reading multiple water quality equipment AAQ1183 type made by JFE-Advantech Co., Ltd.

Turbidity sensor is the infrared ray backward scattering type, and measuring range is from 0 to 1000 FTU in FTU[*1], resolution is 0.03FTU and accuracy is ±0.2%.

*1: FTU (Forumajin Turbidity Unit)

3.3.8 Oxidation-reduction potential (ORP)

ORP was measured by small measuring instrument HM-21P type product of DKK –TOA Corporation. Measuring range is from 0 to 1.999mV and accuracy is ±2mV.

Table-2 Specification of the direct-reading multiple water quality equipment (AAQ1183 type made by JFE-Advantech Co., Ltd.)

Item	Type	Meas. Range	Resolution	Accuracy	Time Constant (sec.)
Deapth	Semi-conductor type pressure gauge	0～100m	0.002m	0.3% FS	0.2
Water Temp.	Thermistor	-5～40°C	0.001°C	±0.02 °C	0.28
Conductivity	Electromagnetic induction cell	0～60ms/cm	0.001ms/cm	±0.02 ms/cm	0.28
Salinity	Practical salinity type	0～40	0.001	±0.03	—
Turbidity	Infrared ray backward scattering type	0～1000FTU	0.03FTU	±2% of m.v.[*1]	0.2
DO	Galvanic electrode type	0～20mg/L	0.01mg/L	±0.2 mg/L	3.5
pH	Glass	0～14 pH	0.01pH	± 0.2	10

*1 ; measured value

4. Results of Measurements

Measurement results are shown as three parts consist of the measurement results relating to the effectiveness of onboard tests, the decision to pass or fail to regulation D-2 and other measurements.

4.1 Measurement results relating to the effectiveness of onboard tests

It is required by G8 guideline that the concentration of organisms in ballast water during uptake should be more than 10 times of D-2.1 specified value of regulation D-2 and the concentration of organisms in ballast tank storing non-treated ballast watert (control ballast tank) should be more than D-2.1 specified value during discharge.

That is, it is necessary that the concentration of L size group organisms in ballast water should be more than 100 ind./m^3, the concentration of S size group should be more than 100 ind./ml during uptake and the concentration of organisms should be more than 10 ind./m^3 for L size and more than 10 ind./ml for S size during discharge.

Mesurement results of this onboard tests indicated that concentration of L size group organisms was 11,551-240,642 ind./m^3, 680-2,210 ind./ml for S size group organisms during uptake and 28,982-336,713 ind./m^3 for L size group, 103-1,280 ind./ml for S size group during discharge. As these results shown that the concentration of organisms all cleared the above stated specified value of regulation D-2, all six test cycles are judged as "Effective Test Cycle".

Measurement results are shown in Table 3.

Table 3 Measurement results relating to the effectiveness of onboard tests

	Ballast water during uptake (before treatment)			Control water during discharge		
Test Cycle	Size group	L	S	Size group	L	S
	Unit	Ind./m^3	Ind./ml	Unit	Ind./m^3	Ind./ml
	Required value	100	100	Required value	10	10
1	Beginning	84,000	1,587	Beginning	273,100	870
	Middle	148,300	680	Middle	336,700	1,190
	End	146,300	800	End	332,000	1,070
	Average	126,200	1,022	Average	313,933	1,043
2	Beginning	169,900	2,210	Beginning	115,800	1,280
	Middle	228,500	1,140	Middle	51,940	880
	End	240,700	890	End	101,000	1,030
	Average	213,033	1,413	Average	89,580	1,063
3	Beginning	74,200	1,680	Beginning	33,750	570
	Middle	157,600	1,310	Middle	28,980	820
	End	59,860	1,000	End	40,200	810
	Average	97,220	1,330	Average	34,310	733
4	Beginning	20,150	880	Beginning	154,400	720
	Middle	20,450	710	Middle	174,400	560

	End	18,620	690	End	203,000	630
	Average	19,740	760	Average	177,267	637
5	Beginning	64,260	1,040	Beginning	66,800	610
	Middle	76,020	1,180	Middle	59,800	900
	End	54,140	1,200	End	70,530	730
	Average	64,807	1,140	Average	65,710	747
6	Beginning	53,130	800	Beginning	49,280	132
	Middle	17,170	860	Middle	43,400	103
	End	11,550	760	End	60,280	118
	Average	27,283	807	Average	50,987	117

4.2 Measurement results relating to the decision to pass or fail to regulation D-2

As stated above, the regulation D-2 specified the pass or fail decision for L size and S size group organisms in D-2.1 and foe bacteria in D-2.2 as in the table below.

Item	Standard value
L size group organisms	less than 10 viable organisms per cubic metre
S size group organisms	less than 10 viable organisms per millilitre
Toxicogenic *Vibrio Cholerae*	1 cfu/100ml
Escherichia Coli.	250 cfu/100ml
Intestinal Enterococci	100 cfu/100ml

Measurement results relating to the decision to pass or fail to regulation D-2 for each test cycle are shown below.

(1) Test cycle 1

As test cycle 1, uptake and discharge works were performed on July 18th and July 20th respectively. Test results for test cycle 1 are shown in Table 4-1.

Number of L size group organisms in treated ballast water was 2, 4 and 1 ind./m^3 for three measurements (beginning, middle, end) respectively, 2 in average. Number of S size group organisms was 1, 0 and 0 ind./ml respectively. In regard to bacteria, Toxicogenic *Viblio Cholerae* was 0 cfu/100ml, *Escherichia Coli* was 0 cfu/100ml and Intestinal Enterococci was 0 cfu/100ml. Therefore, the results of test cycle 1 meet regulation D2.

(2) Test cycle 2

As test cycle 2, uptake and discharge works were performed on July 19th and July 21th respectively. Test results for test cycle 2 are shown in Table 4-2.

Number of L size group organisms in treated ballast water was 0.3, 0.3 and 0 ind./m^3 for three measurements (beginning, middle, end) respectively. Number of S size group organisms was 0, 0 and 0 ind./ml respectively. In regard to bacteria, Toxicogenic *Viblio Cholerae* was 0 cfu/100ml, *Escherichia Coli* was 0 cfu/100ml and Intestinal Enterococci was 0 cfu/100ml. Therefore, the results of test cycle 2 meet regulation D2.

(3) Test cycle 3

As test cycle 3, uptake and discharge works were performed on July 20th and July 22th

respectively. Test results for test cycle 3 are shown in Table 4-3.

Number of L size group organisms in treated ballast water was 0, 0.3 and 0 ind./m^3 for three measurements (beginning, middle, end) respectively. Number of S size group organisms was all 0 ind./ml for three measurements. In regard to bacteria, Toxicogenic *Viblio Cholerae* was 0 cfu/100ml, *Escherichia Coli* was 0 cfu/100ml and Intestinal Enterococci was 0 cfu/100ml. Therefore, the results of test cycle 3 meet regulation D2.

(4) Test cycle 4

As test cycle 4, uptake and discharge works were performed on July 21th and July 23th respectively. Test results for test cycle 4 are shown in Table 4-4.

Number of L size group organisms in treated ballast water was 0, 0 and 0 ind./m^3 for three measurements (beginning, middle, end) respectively. Number of S size group organisms was all 0 ind./ml for three measurements. In regard to bacteria, Toxicogenic *Viblio Cholerae* was 0 cfu/100ml, *Escherichia Coli* was 0 cfu/100ml and Intestinal Enterococci was 0 cfu/100ml. Therefore, the results of test cycle 4 meet regulation D2.

(5) Test cycle 5

As test cycle 5, uptake and discharge works were performed on July 22th and July 24th respectively. Test results for test cycle 5 are shown in Table 4-5.

Number of L size group organisms in treated ballast water was 0, 0 and 0 ind./m^3 for three measurements (beginning, middle, end) respectively. Number of S size group organisms was all 0 ind./ml for three measurements. In regard to bacteria, Toxicogenic *Viblio Cholerae* was 0 cfu/100ml, *Escherichia Coli* was 0 cfu/100ml and Intestinal Enterococci was 0 cfu/100ml. Therefore, the results of test cycle 5 meet regulation D2.

(6) Test cycle 6

As test cycle 6, uptake and discharge works were performed on July 23th and July 25th respectively. Test results for test cycle 5 are shown in Table 4-6.

Number of L size group organisms in treated ballast water was 0, 0 and 0 ind./m^3 for three measurements (beginning, middle, end) respectively. Number of S size group organisms was all 0 ind./ml for three measurements. In regard to bacteria, Toxicogenic *Viblio Cholerae* was 0 cfu/100ml, *Escherichia Coli* was 0 cfu/100ml and Intestinal Enterococci was 0 cfu/100ml. Therefore, the results of test cycle 6 meet regulation D2.

Table 4-1 Results of biological efficacy measurements in test cycle 1

Upatake	18-Jul-09			→	Discharge	20-Jul-09			
	Uptaken water				Treated Water			Control Water	
	Required condition	≧100			Required condition	<10	Measured value for 3 samples	Required condition	≧10
		ind./m3				ind./m3			ind./m3
L size group	Uptake B	84,000		→	Discharge B	2	1,2,3	Disschrge B	273,100
(≧50μm)	M	148,300		→	M	4	6,2,4	M	336,700
	E	146,300		→	E	1	0,2,1	E	332,000
	Average	126,200			Average	2		Average	313,933
	Strd. Dev.	36,560			Strd. Dev.	2		Strd. Dev.	35,441
			<Note>		Controle water: Propagation of rotifer was observed				
					Species in treated water is not observed at uptake				
	Uptaken water				Treated Water			Control Water	
S size group	Required condition	≧100			Required condition	<10	Measured value for 3 samples	Required condition	≧10
		ind./ml				ind./ml			ind./ml
(10-50μm)	Uptake B	1,587		→	Discharge B	1	3,0,0	Discharge B	870
	M	680		→	M	0	0,0,0	M	1,190
	E	800		→	E	0	0,0,0	E	1,070
	Average	1,022			Average	0		Average	1,043
	Strd. Dev.	493			Strd. Dev.	1		Strd. Dev.	162

Bacteria	Uptaken water				Treated Water			Control Water	
Vibrio sp.	Required condition	none			Required condition	none	Treated water /Uptake		none
	Unit	cfu/100ml				cfu/100ml			cfu/100ml
Including *Cholerae*	Uptake B	3.3E+04		→	Discharge B	70	2.1E-03	Discharge B	2.8E+04
(A part of *Vibrio*)	M	5.4E+04		→	M	55	1.0E-03	M	1.5E+05
	E	5.3E+04		→	E	45	8.5E-04	E	3.4E+04
	Average	47,052			Average	57	1.2E-03	Average	72,222
	Strd. Dev.	11,783			Strd. Dev.	13		Strd. Dev.	71,477
	Uptaken water				Treated Water			Control Water	
Vibrio cholerae	Required condition	none			Required condition	<1(Toxicogenic)			none
		cfu/100ml				cfu/100ml			cfu/100ml
(Incl. Toxicogenic	Uptake B	0		→	Discharge B	0		Discharge B	0
Viblio Cholerae)	M	0		→	M	0		M	0
	E	0		→	E	0		E	0
	Average	–			Average	–		Average	–
	Strd. Dev.	–			Strd. Dev.	–		Strd. Dev.	–
	Uptaken water				Treated Water			Control Water	
Coliform bacteria	Required condition	none			Required condition	none			none
		cfu/100ml				cfu/100ml			cfu/100ml
	Uptake B	14		→	Discharge B	0		Discharge B	48
	M	21		→	M	0		M	72
	E	23		→	E	0		E	15
	Average	19			Average	–		Average	45
	Strd. Dev.	5			Strd. Dev.	–		Strd. Dev.	29
	Uptaken water				Treated Water			Control Water	
Escherichia coli	Required condition	none			Required condition	<250			none
		cfu/100ml				cfu/100ml			cfu/100ml
	Uptake B	8		→	Discharge B	0		Discharge B	4
	M	7		→	M	0		M	7
	E	7		→	E	0		E	7
	Average	7			Average	–		Average	6
	Strd. Dev.	1			Strd. Dev.	–		Strd. Dev.	2
	Uptaken water				Treated Water			Control Water	
Enterococcus Group	Required condition	none			Required condition	Intestinal *Enterococci* <100)			none
		cfu/100ml				cfu/100ml			cfu/100ml
	Uptake B	38		→	Discharge B	0		Discharge B	2
	M	34		→	M	0		M	1
	E	3		→	E	0		E	2
	Average	25			Average	–		Average	2
	Strd. Dev.	19			Strd. Dev.	–		Strd. Dev.	1
	Uptaken water				Treated Water			Control Water	
Heterotrophic bacteria	Required condition	none			Required condition	none	Treated water /Uptake		none
		cfu/100ml				cfu/100ml			cfu/100ml
	Uptake B	9.1E+05		→	Discharge B	1.0E+03	1.1E-03	Discharge B	6.0E+05
	M	9.2E+05		→	M	9.7E+02	1.1E-03	M	7.0E+05
	E	6.8E+05		→	E	1.0E+03	1.5E-03	E	1.7E+06
	Average	8.4E+05			Average	9.9E+02	1.2E-03	Average	1.0E+06
	Strd. Dev.	1.4E+05			Strd. Dev.	1.7E+01		Strd. Dev.	6.1E+05

Table 4-2 Results of biological efficacy measurements in test cycle 2

Upatake	19-Jul-09			→	Discharge	21-Jul-09		
	Uptake water				Treated Water			Control Water
	Required condition	≧100			Required condition	<10	Measured value for 3 samples	Required condition	≧10	
		ind./m3				ind./m3			ind./m3	
L size group	Uptake B	169,900	ind./m3	→	Dischrge B	0.3	1,0,0	Discharge B	115,800	ind./m3
(≧50μm)	M	228,500			M	0.3	1,0,0	M	51,940	
	E	240,700			E	0	0,0,0	E	101,000	
	Average	213,033			Average	0		Average	89,580	
	Strd. Dev.	37,849			Strd. Dev.	0		Strd. Dev.	33,427	
	Uptake water				Treated Water			Control Water		
S size group	Required condition	≧100			Required condition	<10	Measured value for 3 samples	Required condition	≧10	
		ind./ml				ind./ml			ind./ml	
(10-50μm)	Uptake B	2,210		→	Dischrge B	0	0,0,0	Dischrge B	1,280	
	M	1,140			M	0	0,0,0	M	880	
	E	890			E	0	0,0,0	E	1,030	
	Average	1,413			Average	0		Average	1,063	
	Strd. Dev.	701			Strd. Dev.	-		Strd. Dev.	202	

Bacteria	Uptake water				Treated Water			Control Water		
Vibrio sp.	Required condition	none			Required condition	none	Treated water /Uptake		none	
	Unit	cfu/100ml				cfu/100ml			cfu/100ml	
Including *Cholerae*	Uptake B	4.4E+04		→	Discharge B	107	2.4E-03	Discharge B	8.7E+04	
(A part of *Vibrio*)	M	3.5E+04		→	M	70	2.0E-03	M	6.9E+04	
	E	3.2E+04		→	E	34	1.1E-03	E	4.9E+04	
	Average	3.7E+04			Average	70	1.9E-03	Average	6.9E+04	
	Strd. Dev.	6.3E+03			Strd. Dev.	37		Strd. Dev.	1.9E+04	
	Uptake water				Treated Water			Control Water		
Vibrio cholerae	Required condition	none			Required condition	<1(Toxicogenic)			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
(Incl. Toxicogenic	Uptake B	0		→	Discharge B	0		Discharge B	0	
Viblio Cholerae)	M	0		→	M	0		M	0	
	E	0		→	E	0		E	0	
	Average	-			Average	-		Average	-	
	Strd. Dev.	-			Strd. Dev.	-		Strd. Dev.	-	
	Uptake water				Treated Water			Control Water		
Coliform bacteria	Required condition	none			Required condition	none			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	268		→	Discharge B	1		Discharge B	22	
	M	47		→	M	0		M	11	
	E	59		→	E	0		E	5	
	Average	125			Average	0		Average	13	
	Strd. Dev.	124			Strd. Dev.	1		Strd. Dev.	9	
	Uptaken water				Treated Water			Control Water		
Escherichia coli	Required condition	none			Required condition	<250			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	32	cfu/100ml	→	Discharge B	0		Discharge B	8	
	M	15		→	M	0		M	8	
	E	17		→	E	0		E	2	
	Average	21			Average	-		Average	6	
	Strd. Dev.	9			Strd. Dev.	-		Strd. Dev.	3	
	Uptaken water				Treated Water			Control Water		
Enterococcus Group	Required condition	none			Required condition	Intestinal *Enterococci* <100)			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	56	cfu/100ml	→	Discharge B	0		Discharge B	3	
	M	22		→	M	0		M	3	
	E	53		→	E	0		E	5	
	Average	44			Average	-		Average	4	
	Strd. Dev.	19			Strd. Dev.	-		Strd. Dev.	1	
	Uptaken water				Treated Water			Control Water		
Heterotrophic bacteria	Required condition	none			Required condition	none	Treated water /Uptake		none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	8.9E+05	cfu/100ml	→	Discharge B	4.1E+02	4.6E-04	Discharge B	7.0E+05	
	M	1.2E+05		→	M	4.5E+02	3.8E-03	M	6.5E+05	
	E	2.1E+06		→	E	4.9E+02	2.3E-04	E	4.9E+04	
	Average	1.0E+06			Average	4.5E+02	4.3E-04	Average	4.7E+05	
	Strd. Dev.	1.0E+06			Strd. Dev.	4.0E+01		Strd. Dev.	3.6E+05	

Table 4-3 Results of biological efficacy measurements in test cycle 3

Upatake		20-Jul-09		→	Discharge			22-Jul-09		
	Uptaken water				Treated Water			Control Water		
	Required condition	≧100			Required condition	<10	Measured value for 3 samples	Required condition	≧10	
		ind./m3				ind./m3			ind./m3	
L size group	Uptake B	74,200		→	Discharge B	0	0,0,0	Disschrge B	33,750	ind./m3
(≧50μm)	M	157,600			M	0.3	0,1,0	M	28,980	
	E	59,860			E	0	0,0,0	E	40,200	
	Average	97,220			Average	0		Average	34,310	
	Strd. Dev.	52,780			Strd. Dev.	0		Strd. Dev.	5,631	
	Uptaken water				Treated Water			Control Water		
S size group	Required condition	≧100			Required condition	<10	Measured value for 3 samples	Required condition	≧10	
		ind./ml				ind./ml			ind./ml	
(10-50μm)	Uptake B	1,680	ind./ml	→	Discharge B	0	0,0,0	Discharge B	570	ind./ml
	M	1,310			M	0	0,0,0	M	820	
	E	1,000			E	0	0,0,0	E	810	
	Average	1,330			Average	0		Average	733	
	Strd. Dev.	340			Strd. Dev.	0		Strd. Dev.	142	

Bacteria	Uptaken water				Treated Water			Control Water		
Vibrio sp.	Required condition	none			Required condition	none	Treated water /Uptake		none	
	Unit	cfu/100ml				cfu/100ml			cfu/100ml	
Including *Cholerae*	Uptake B	3.0E+04		→	Discharge B	165	5.5E-03	Discharge B	4.0E+03	
(A part of *Vibrio*)	M	1.3E+03		→	M	48	3.6E-02	M	3.4E+04	
	E	6.0E+03		→	E	55	9.2E-03	E	3.0E+04	
	Average	1.2E+04			Average	89	7.2E-03	Average	22,778	
	Strd. Dev.	1.5E+04			Strd. Dev.	66		Strd. Dev.	16,406	
	Uptaken water				Treated Water			Control Water		
Vibrio cholerae	Required condition	none			Required condition	<1(Toxicogenic)			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
(Incl. Toxicogenic	Uptake B	0	cfu/100ml	→	Discharge B	0		Discharge B	0	
Viblio Cholerae)	M	0		→	M	0		M	0	
	E	0		→	E	0		E	0	
	Average	0			Average	0		Average	0	
	Strd. Dev.	0			Strd. Dev.	0		Strd. Dev.	0	
	Uptaken water				Treated Water			Control Water		
Coliform bacteria	Required condition	none			Required condition	none			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	61		→	Discharge B	0		Discharge B	14	cfu/100ml
	M	60		→	M	0		M	16	
	E	43		→	E	0		E	15	
	Average	55			Average	0		Average	15	
	Strd. Dev.	10			Strd. Dev.	0		Strd. Dev.	1	
	Uptaken water				Treated Water			Control Water		
Escherichia coli	Required condition	none			Required condition	<250			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	41		→	Discharge B	0		Discharge B	8	
	M	27		→	M	0		M	7	
	E	25		→	E	0		E	3	
	Average	31			Average	0		Average	6	
	Strd. Dev.	9			Strd. Dev.	0		Strd. Dev.	3	
	Uptaken water				Treated Water			Control Water		
Enterococcus Group	Required condition	none			Required condition	Intestinal *Enterococci* <100)			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	39	cfu/100ml	→	Discharge B	0		Discharge B	1	
	M	33		→	M	0		M	2	
	E	39		→	E	0		E	3	
	Average	37			Average	0		Average	2	
	Strd. Dev.	3			Strd. Dev.	0		Strd. Dev.	1	
	Uptaken water				Treated Water			Control Water		
Heterotrophic bacteria	Required condition	none			Required condition	none	Treated water /Uptake		none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	1.8E+06	cfu/100ml	→	Discharge B	2.1E+02	1.2E-04	Discharge B	1.9E+06	
	M	3.2E+06		→	M	2.3E+02	7.2E-05	M	4.9E+05	
	E	4.1E+06		→	E	1.1E+02	2.7E-05	E	6.2E+05	
	Average	3.0E+06			Average	1.8E+02	6.0E-05	Average	1.0E+06	
	Strd. Dev.	1.2E+06			Strd. Dev.	6.4E+01		Strd. Dev.	7.8E+05	

Table 4-4 Results of biological efficacy measurements in test cycle 4

Uptake	21-Jul-09	→	Discharge	23-Jul-09

	Uptaken water			Treated Water			Control Water	
	Required condition	≧100		Required condition	<10	Measured value for 3 samples	Required condition	≧10
		ind./m3			ind./m3			ind./m3
L size group	Uptake B	20,150	→	Discharge B	0	0,0,0		154,400
(≧50μm)	M	20,450		M	0	0,0,0		174,400
	E	18,620		E	0	0,0,0		203,000
	Average	19,740		Average	0		Average	177,267
	Strd. Dev.	981		Strd. Dev.	0		Strd. Dev.	24,426
	Uptaken water			**Treated Water**			**Control Water**	
S size group	Required condition	≧100		Required condition	<10	Measured value for 3 samples	Required condition	≧10
		ind./ml			ind./ml			ind./ml
(10～50μm)	Uptake B	880	→	Discharge B	0	0,0,0	Discharge B	720
	M	710		M	0	0,0,0	M	560
	E	690		E	0	0,0,0	E	610
	Average	760		Average	0		Average	630
	Strd. Dev.	104		Strd. Dev.	0		Strd. Dev.	82

Bacteria	**Uptaken water**			**Treated Water**			**Control Water**	
Vibrio sp.	Required condition	none		Required condition	none	Treated water /Uptake		none
	Unit	cfu/100ml			cfu/100ml			cfu/100ml
Including *Cholerae*	Uptake B	3.7E+03	→	Discharge B	102	2.8E-02	Discharge B	2.1E+04
(A part of *Vibrio*)	M	8.0E+03	→	M	14	1.8E-03	M	1.6E+04
	E	2.4E+04	→	E	65	2.7E-03	E	2.5E+04
	Average	1.2E+04		Average	60	5.1E-03	Average	2.1E+04
	Strd. Dev.	1.1E+04		Strd. Dev.	44		Strd. Dev.	4.5E+03
	Uptaken water			**Treated Water**			**Control Water**	
Vibrio cholerae	Required condition	none		Required condition	<1(Toxicogenic)			none
		cfu/100ml			cfu/100ml			cfu/100ml
(Incl. Toxicogenic	Uptake B	0	→	Discharge B	0		Discharge B	0
Viblio Cholerae)	M	0	→	M	0		M	0
	E	0	→	E	0		E	0
	Average	0		Average	0		Average	0
	Strd. Dev.	0		Strd. Dev.	0		Strd. Dev.	0
	Uptaken water			**Treated Water**			**Control Water**	
Coliform bacteria	Required condition	none		Required condition	none			none
		cfu/100ml			cfu/100ml			cfu/100ml
	注入 前	34	→	排出 前	0		cfu/100ml	12
	中	40	→	中	0			10
	後	33	→	後	0			12
	平均	36		平均	0		平均	11
	標準偏差	4		標準偏差	0		標準偏差	1
	Uptaken water			**Treated Water**			**Control Water**	
Escherichia coli	Required condition	none		Required condition	<250			none
		cfu/100ml			cfu/100ml			cfu/100ml
	Uptake B	9	→	Discharge B	0		Discharge B	4
	M	5	→	M	0		M	3
	E	2	→	E	0		E	2
	Average	5		Average	0		Average	3
	Strd. Dev.	4		Strd. Dev.	0		Strd. Dev.	1
	Uptaken water			**Treated Water**			**Control Water**	
Enterococcus Group	Required condition	none		Required condition	Intestinal *Enterococci* <100)			none
		cfu/100ml			cfu/100ml			cfu/100ml
	Uptake B	80	→	Discharge B	0		Discharge B	0
	M	44	→	M	0		M	1
	E	16	→	E	0		E	1
	Average	47		Average	0		Average	1
	Strd. Dev.	32		Strd. Dev.	0		Strd. Dev.	1
	Uptaken water			**Treated Water**			**Control Water**	
Heterotrophic bacteria	Required condition	none		Required condition	none	Treated water /Uptake		none
		cfu/100ml			cfu/100ml			cfu/100ml
	Uptake B	7.8E+05	→	Discharge B	2.3E+02	2.9E-04	Discharge B	2.4E+05
	M	6.9E+05	→	M	3.0E+02	4.3E-04	M	1.0E+06
	E	3.3E+05	→	E	2.3E+02	7.0E-04	E	2.0E+05
	Average	6.0E+05		Average	2.5E+02	4.2E-04	Average	4.8E+05
	Strd. Dev.	2.4E+05		Strd. Dev.	4.0E+01		Strd. Dev.	4.5E+05

Table 4-5 Results of biological efficacy measurements in test cycle 5

Uptake	22-Jul-09			→	Discharge			24-Jul-09		
	Uptaken water				Treated Water			Control Water		
	Required condition	≧100			Required condition	<10	Measured value for 3 samples	Required condition	≧10	
		ind./m3				ind./m3			ind./m3	
L size group	Uptake B	64,260		→	Discharge B	0	0,0,0	Disschrge B	66,800	
(≧50μm)	M	76,020			M	0	0,0,0	M	59,800	
	E	54,140			E	0	0,0,0	E	70,530	
	Average	64,807			Average	0		Average	65,710	
	Strd. Dev.	10,950			Strd. Dev.	0		Strd. Dev.	5,447	
	Uptaken water				Treated Water			Control Water		
S size group	Required condition	≧100			Required condition	<10	Measured value for 3 samples	Required condition	≧10	
		ind./ml				ind./ml			ind./ml	
(10～50μm)	Uptake B	1,040		→	Discharge B	0	0,0,0	Discharge B	610	
	M	1,180			M	0	0,0,0	M	900	
	E	1,200			E	0	0,0,0	E	730	
	Average	1,140			Average	0		Average	747	
	Strd. Dev.	87			Strd. Dev.	0		Strd. Dev.	146	
Bacteria	Uptaken water				Treated Water			Control Water		
Vibrio sp.	Required condition	none			Required condition	none	Treated water /Uptake		none	
	Unit	cfu/100ml				cfu/100ml			cfu/100ml	
Including *Cholerae*	Uptake B	1.3E+04		→	Discharge B	16	1.2E-03	Discharge B	8.3E+03	
(A part of *Vibrio*)	M	9.3E+03		→	M	1	1.1E-04	M	1.8E+04	
	E	5.0E+03		→	E	29	5.8E-03	E	7.3E+03	
	Average	9.1E+03			Average	15	1.7E-03	Average	1.1E+04	
	Strd. Dev.	4.0E+03			Strd. Dev.	14		Strd. Dev.	5.9E+03	
	Uptaken water				Treated Water			Control Water		
Vibrio cholerae	Required condition	none			Required condition	<1(Toxicogenic)			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
Including *Cholerae*	Uptake B	0		→	Discharge B	0		Discharge B	0	cfu/100ml
(A part of *Vibrio*)	M	0		→	M	0		M	0	
	E	0		→	E	0		E	0	
	Average	0			Average	0		Average	0	
	Strd. Dev.	0			Strd. Dev.	0		Strd. Dev.	0	
	Uptaken water				Treated Water			Control Water		
Coliform bacteria	Required condition	none			Required condition	none			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	54		→	Discharge B	0		Discharge B	27	
	M	49		→	M	0		M	8	
	E	61		→	E	0		E	10	
	Average	55			Average	0		Average	15	
	Strd. Dev.	6			Strd. Dev.	0		Strd. Dev.	10	
	Uptaken water				Treated Water			Control Water		
Escherichia coli	Required condition	none			Required condition	<250			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	18		→	Discharge B	0		Discharge B	6	
	M	19		→	M	0		M	2	
	E	22		→	E	0		E	3	
	Average	20			Average	0		Average	4	
	Strd. Dev.	2			Strd. Dev.	0		Strd. Dev.	2	
	Uptaken water				Treated Water			Control Water		
Enterococcus Group	Required condition	none			Required condition	Intestinal *Enterococci* <100)			none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	173		→	Discharge B	0		Discharge B	0	
	M	8		→	M	0		M	0	
	E	4		→	E	0		E	2	
	Average	62			Average	0		Average	1	
	Strd. Dev.	96			Strd. Dev.	0		Strd. Dev.	1	
	Uptaken water				Treated Water			Control Water		
Heterotrophic bacteria	Required condition	none			Required condition	none	Treated water /Uptake		none	
		cfu/100ml				cfu/100ml			cfu/100ml	
	Uptake B	9.6E+05		→	Discharge B	1.3E+03	1.4E-03	Discharge B	1.5E+05	
	M	6.0E+05		→	M	1.5E+03	2.5E-03	M	1.7E+05	
	E	1.1E+06		→	E	3.8E+03	3.5E-03	E	1.6E+05	
	Average	8.9E+05			Average	2.2E+03	2.5E-03	Average	1.6E+05	
	Strd. Dev.	2.6E+05			Strd. Dev.	1.4E+03		Strd. Dev.	1.0E+04	

Table 4-6 Results of biological efficacy measurements in test cycle 6

Uptake 23-Jul-09 → **Discharge** 25-Jul-09

		Uptaken water			Treated Water			Control Water	
	Required condition	≧100			Required condition	<10	Measured value for 3 samples	Required condition	≧10
		ind./m3				ind./m3			ind./m3
L size group	Uptake B	53,130		→	Discharge B	0	0,0,0	Disschrge B	49,280
(≧50μm)	M	17,170			M	0	0,0,0	M	43,400
	E	11,550			E	0	0,0,0	E	60,280
	Average	27,283			Average	0		Average	50,987
	Strd. Dev.	22,560			Strd. Dev.	0		Strd. Dev.	8,568
		Uptaken water			Treated Water			Control Water	
S size group	Required condition	≧100			Required condition	<10	Measured value for 3 samples	Required condition	≧10
		ind./ml				ind./ml			ind./ml
(10～50μm)	Uptake B	800		→	Discharge B	0	0,0,0	Discharge B	132
	M	860			M	0	0,0,0	M	103
	E	760			E	0	0,0,0	E	118
	Average	807			Average	0		Average	117
	Strd. Dev.	50			Strd. Dev.	0		Strd. Dev.	14

Bacteria		Uptaken water			Treated Water			Control Water	
Vibrio sp.	Required condition	none			Required condition	none	Treated water /Uptake		none
	Unit	cfu/100ml				cfu/100ml			cfu/100ml
Including *Cholerae*	Uptake B	7.3E+03		→	Discharge B	15	2.1E-03	Discharge B	9.7E+03
(A part of *Vibrio*)	M	8.3E+03		→	M	13	1.6E-03	M	1.6E+04
	E	3.0E+04		→	E	33	1.1E-03	E	3.1E+04
	Average	1.5E+04			Average	20	1.3E-03	Average	1.9E+04
	Strd. Dev.	1.3E+04			Strd. Dev.	11		Strd. Dev.	1.1E+04
		Uptaken water			Treated Water			Control Water	
Vibrio cholerae	Required condition	none			Required condition	<1(Toxicogenic)			none
		cfu/100ml				cfu/100ml			cfu/100ml
Including *Cholerae*	Uptake B	0	cfu/100m	→	Discharge B	0		Discharge B	0
(A part of *Vibrio*)	M	0		→	M	0		M	0
	E	0		→	E	0		E	0
	Average	0			Average	0		Average	0
	Strd. Dev.	0			Strd. Dev.	0		Strd. Dev.	0
		Uptaken water			Treated Water			Control Water	
Coliform bacteria	Required condition	none			Required condition	none			none
		cfu/100ml				cfu/100ml			cfu/100ml
	Uptake B	192	cfu/100m	→	Discharge B	0		Discharge B	143
	M	277		→	M	0		M	201
	E	339		→	E	1		E	121
	Average	269			Average	0	1.2E-03	Average	155
	Strd. Dev.	74			Strd. Dev.	1		Strd. Dev.	41
		Uptaken water			Treated Water			Control Water	
Escherichia coli	Required condition	none			Required condition	<250			none
		cfu/100ml				cfu/100ml			cfu/100ml
	Uptake B	24	cfu/100m	→	Discharge B	0		Discharge B	11
	M	32		→	M	0		M	15
	E	33		→	E	0		E	11
	Average	30			Average	0		Average	12
	Strd. Dev.	5			Strd. Dev.	0		Strd. Dev.	2
		Uptaken water			Treated Water			Control Water	
Enterococcus Group	Required condition	none			Required condition	Intestinal *Enterococci* <100)			none
		cfu/100ml				cfu/100ml			cfu/100ml
	Uptake B	5	cfu/100m	→	Discharge B	0		Discharge B	1
	M	11		→	M	0		M	2
	E	10		→	E	0		E	2
	Average	9			Average	0		Average	2
	Strd. Dev.	3			Strd. Dev.	0		Strd. Dev.	1
		Uptaken water			Treated Water			Control Water	
Heterotrophic bacteria	Required condition	none			Required condition	none	Treated water /Uptake		none
		cfu/100ml				cfu/100ml			cfu/100ml
	Uptake B	5.1E+05	cfu/100m	→	Discharge B	1.3E+03	2.5E-03	Discharge B	1.5E+05
	M	6.3E+05		→	M	1.5E+03	2.4E-03	M	1.7E+05
	E	1.6E+06		→	E	3.8E+03	2.4E-03	E	1.6E+05
	Average	9.1E+05			Average	2.2E+03	2.4E-03	Average	1.6E+05
	Strd. Dev.	6.0E+05			Strd. Dev.	1.4E+03		Strd. Dev.	1.0E+04

4.3 Water quality measurements based on the requirements of onboard tests

According to the requirements on onboard tests, the measurement on water temperature, salinity, POC and TSS are required. Along with these items, DO, turbidity, pH and ORP were measured in these onboard tests at the same time.

(1) Test cycle 1

Measurement results are shown in Table 5-1 Measurement results of water quality in test cycle 1. As test cycle 1, uptake and discharge works were performed on July 18th and July 20th respectively.

Water temperature was between 27.48-28.13°C during uptake and 27.31-28.07°C during discharge. Salinity was between 28.21-28.62 PSU during uptake and 28.45-28.60 PSU during discharge. POC was 0.3-1.0 mg/L during uptake and 0.1-0.6 mg/L during discharge. TSS was between 3.1-4.3 mg/L during uptake and 1.7-2.7 mg/L during discharge.

Table 5-1 Measured results of water quality of test cycle-1

Test cycle 1 **Uptake** **18th July, 2009** **Discharge** **20th July, 2009**

	Unit	Uptake		
		Uptake (B)	Uptake (M)	Uptake (E)
Water Temp.	°C	28.13	27.48	27.84
Salinity	PSU	28.21	28.62	28.34
pH		8.54	8.48	8.57
Turbidity	NTU	11.69	6.39	7.16
DO	mg/l	7.51	6.94	7.36
ORP	mV	211	218	213
TSS	mg/L	3.4	3.9	4.3
POC	mg/L	1	0.5	0.3

	Unit	Treated			Control
		Discharge (B)	Discharge (B)	Discharge (B)	Uptake (B)
Water Temp	°C	27.31	27.46	27.46	27.51
Salinity	PSU	28.52	28.53	28.53	28.6
pH		8.48	8.5	8.5	8.41
Turbidity	NTU	7.64	8.02	7.8	16.53
DO	mg/l	6.68	6.68	6.82	6.7
ORP	mV	216	185	196	200
TSS	mg/L	2.2	1.9	2.1	2.3
POC	mg/L	0.4	0.6	0.1	0.2

	Unit	Treated			Control
		Discharge (M)	Discharge (M)	Discharge (M)	Uptake (M)
Water Temp	°C	27.5	27.5	27.77	27.71
Salinity	PSU	28.52	28.5	28.48	28.56
pH		8.5	8.5	8.5	8.42
Turbidity	NTU	4.31	3.02	6.19	5.41
DO	mg/l	6.68	6.69	6.86	6.65
ORP	mV	196	204	196	200
TSS	mg/L	1.7	2	2.2	2.6
POC	mg/L	0.5	0.1	0.3	0.3

	Unit	Treated			Control
		Discharge (E)	Discharge (E)	Discharge (E)	Uptake (E)
Water Temp	°C	27.87	27.95	27.99	28.07
Salinity	PSU	28.47	28.46	28.45	28.48
pH		8.5	8.5	8.49	8.41
Turbidity	NTU	4.5	3.97	4.18	9.33
DO	mg/l	6.76	6.77	6.79	6.61
ORP	mV	207	190	179	181
TSS	mg/L	1.9	1.7	2.7	2.3
POC	mg/L	0.1	0.4	0.2	0.5

(2) Test cycle 2

Measurement results are shown in Table 5-2 Measurement results of water quality in test cycle 2. As test cycle 1, uptake and discharge works were performed on July 19th and July 21st respectively.

Water temperature was between 27.13-27.53°C during uptake and 26.98-27.26°C during discharge. Salinity was between 29.75-29.85 PSU during uptake and 29.84-29.90 PSU during discharge. POC was 0.3-0.9 mg/L during uptake and 0.1-0.7 mg/L during discharge. TSS was between 4.3-4.5 mg/L during uptake and 1.9-4.6 mg/L during discharge.

Table 5-2 Measured results of water quality of test cycle-2

Test cycle 2 **Uptake** **19th July, 2009** **Discharge** **21th July, 2009**

	Unit	Uptake		
		Uptake (B)	Uptake (M)	Uptake (E)
Water Temp.	°C	27.2	27.58	27.13
Salinity	PSU	29.78	29.75	29.85
pH		8.29	8.42	8.38
Turbidity	NTU	8.1	8.84	5.75
DO	mg/l	7.1	6.78	6.85
ORP	mV	240	218	212
TSS	mg/L	4.3	4.5	4.4
POC	mg/L	0.5	0.3	0.9

	Unit	Treated			Control
		Discharge (B)	Discharge (B)	Discharge (B)	Uptake (B)
Water Temp	°C	26.98	27.05	27.07	27.02
Salinity	PSU	29.88	29.85	29.87	29.89
pH		8.33	8.33	8.31	8.25
Turbidity	NTU	5.66	7	7.78	7.33
DO	mg/l	6.76	6.75	6.73	6.7
ORP	mV	178	180	174	178
TSS	mg/L	1.9	2.4	2.3	4.5
POC	mg/L	0.2	0.2	0.1	0.5

	Unit	Treated			Control
		Discharge (M)	Discharge (M)	Discharge (M)	Uptake (M)
Water Temp	°C	27.15	27.16	27.23	27.21
Salinity	PSU	29.86	29.86	29.84	29.9
pH		8.32	8.33	8.33	8.28
Turbidity	NTU	5.68	5.77	5.78	1.3
DO	mg/l	6.88	6.8	6.78	6.64
ORP	mV	182	177	196	185
TSS	mg/L	2.2	2.9	2.7	4.6
POC	mg/L	0.3	0.1	0.4	0.7

	Unit	Treated			Control
		Discharge (E)	Discharge (E)	Discharge (E)	Uptake (E)
Water Temp	°C	27.26	27.26	27.24	27.26
Salinity	PSU	29.86	29.88	29.87	29.85
pH		8.34	8.33	8.33	8.25
Turbidity	NTU	5.52	5.37	6.44	13.45
DO	mg/l	6.81	6.81	6.81	6.67
ORP	mV	181	178	197	181
TSS	mg/L	3.3	3.1	3.5	4.1
POC	mg/L	0.3	0.5	0.5	0.6

(3) Test cycle 3

Measurement results are shown in Table 5-3 Measurement results of water quality in test cycle 3. As test cycle 3, uptake and discharge works were performed on July 20th and July 22nd respectively.

Water temperature was between 27.06-27.16°C during uptake and 26.97-27.18°C during discharge. Salinity was between 26.75-26.98 PSU during uptake and 26.78-27.16 PSU during discharge. POC was 0.4-0.6 mg/L during uptake and 0.1-0.3 mg/L during discharge. TSS was between 3.8-4.7 mg/L during uptake and 2.0-3.8 mg/L during discharge.

Table 5-3 Measured results of water quality of test cycle-3

Test cycle 3 **Uptake** **20th July, 2009** **Discharge** **22th July, 2009**

	Unit	Uptake		
		Uptake (B)	Uptake (M)	Uptake (E)
Water Temp.	°C	27.09	27.06	27.16
Salinity	PSU	26.75	26.98	27.06
pH		8.55	8.53	8.53
Turbidity	NTU	4.25	1.4	4.95
DO	mg/l	7.3	7.36	7.19
ORP	mV	165	197	177
TSS	mg/L	4.1	4.7	3.8
POC	mg/L	0.4	0.6	0.5

	Unit	Treated			Control
		Discharge (B)	Discharge (B)	Discharge (B)	Uptake (B)
Water Temp	°C	26.97	27	26.99	26.97
Salinity	PSU	26.96	26.96	26.97	27.14
pH		8.5	8.49	8.48	8.4
Turbidity	NTU	2.54	3.6	4.8	5.62
DO	mg/l	6.27	6.62	6.48	6.73
ORP	mV	176	178	180	178
TSS	mg/L	2.1	2	2	3.8
POC	mg/L	0.1	0.2	0.3	0.1

	Unit	Treated			Control
		Discharge (M)	Discharge (M)	Discharge (M)	Uptake (M)
Water Temp	°C	27.11	27.16	27.15	27.14
Salinity	PSU	26.88	27.16	26.81	27.06
pH		8.5	8.51	8.52	8.41
Turbidity	NTU	4.38	3.38	5.5	4.18
DO	mg/l	6.61	6.49	6.69	6.82
ORP	mV	182	180	177	191
TSS	mg/L	2.4	2.2	2.3	4.4
POC	mg/L	0.2	0.3	0.1	0.1

	Unit	Treated			Control
		Discharge (E)	Discharge (E)	Discharge (E)	Uptake (E)
Water Temp	°C	27.15	27.16	27.14	27.18
Salinity	PSU	26.78	26.83	26.83	27.02
pH		8.51	8.52	8.52	8.41
Turbidity	NTU	4.75	11.07	5.31	19.78
DO	mg/l	6.61	6.59	6.48	6.78
ORP	mV	177	178	175	181
TSS	mg/L	2.3	2.9	2.8	3.8
POC	mg/L	0.1	0.1	0.1	0.1

(4) Test cycle 4

Measurement results are shown in Table 5-4 Measurement results of water quality in test cycle 4. As test cycle 4, uptake and discharge works were performed on July 21st and July 23rd respectively.

Water temperature was between 26.96-27.43°C during uptake and 27.14-27.55°C during discharge. Salinity was between 27.67-28.98PSU during uptake and 26.78-28.52PSU during discharge. POC was 0.4-0.5 mg/L during uptake and 0.1-0.4 mg/L during discharge. TSS was between 3.7-4.9 mg/L during uptake and 2.4-4.5 mg/L during discharge.

Table 5-4 Measured results of water quality of test cycle-4

Test cycle 4 **Uptake** **21th July, 2009** **Discharge** **23th July, 2009**

	Unit	Uptake		
		Uptake (B)	Uptake (M)	Uptake (E)
Water Temp.	°C	27.27	27.43	26.96
Salinity	PSU	27.67	28.59	28.98
pH		8.33	8.26	8.23
Turbidity	NTU	5.8	9.42	7.68
DO	mg/l	6.67	6.42	6.01
ORP	mV	189	187	176
TSS	mg/L	4.9	3.9	3.7
POC	mg/L	0.5	0.4	0.5

	Unit	Treated			Control
		Discharge (B)	Discharge (B)	Discharge (B)	Uptake (B)
Water Temp	°C	27.23	27.27	27.36	27.34
Salinity	PSU	28.52	28.52	28.5	28.48
pH		8.14	8.19	8.05	8.03
Turbidity	NTU	4.34	6.67	6.23	6.47
DO	mg/l	5.69	5.92	5.4	5.78
ORP	mV	186	183	182	195
TSS	mg/L	2.4	2.6	3.1	4.5
POC	mg/L	0.1	0.3	0.1	0.2

	Unit	Treated			Control
		Discharge (M)	Discharge (M)	Discharge (M)	Uptake (M)
Water Temp	°C	27.45	27.54	27.45	27.55
Salinity	PSU	28.48	28.52	28.52	28.45
pH		8.05	8.21	8.22	8.05
Turbidity	NTU	5.78	7.21	6.78	3.09
DO	mg/l	5.58	5.83	5.95	5.78
ORP	mV	189	191	194	186
TSS	mg/L	2.8	2.6	2.5	4.5
POC	mg/L	0.1	0.2	0.3	0.2

	Unit	Treated			Control
		Discharge (E)	Discharge (E)	Discharge (E)	Uptake (E)
Water Temp	°C	27.15	27.16	27.14	27.74
Salinity	PSU	26.78	26.83	26.83	28.49
pH		8.51	8.52	8.52	8.16
Turbidity	NTU	4.75	11.07	5.31	4.68
DO	mg/l	6.61	6.59	6.48	6.12
ORP	mV	170	177	178	181
TSS	mg/L	3	2.8	3.5	4.2
POC	mg/L	0.3	0.1	0.4	0.1

(5) Test cycle 5

Measurement results are shown in Table 5-5 Measurement results of water quality in test cycle 5. As test cycle 5, uptake and discharge works were performed on July 22nd and July 24th respectively.

Water temperature was between 26.83-26.96°C during uptake and 27.07-27.82°C during discharge. Salinity was between 25.89-26.18PSU during uptake and 26.03-26.302PSU during discharge. POC was 0.1-0.2 mg/L during uptake and 0.1-0.3 mg/L during discharge. TSS was between 3.6-4.7 mg/L during uptake and 1.3-2.5 mg/L during discharge.

Table 5-5 Measured results of water quality of test cycle-5

Test cycle 5 **Uptake** **22th July, 2009** **Discharge** **24th July, 2009**

		Uptake		
	Unit	Uptake (B)	Uptake (M)	Uptake (E)
Water Temp.	°C	26.83	26.96	26.91
Salinity	PSU	26.18	25.89	26.02
pH		8.48	8.51	8.5
Turbidity	NTU	7.02	5.42	4.02
DO	mg/l	7.24	7.16	7.27
ORP	mV	198	186	192
TSS	mg/L	4.7	4.5	3.6
POC	mg/L	0.1	0.2	0.2

		Treated			Control
	Unit	Discharge (B)	Discharge (B)	Discharge (B)	Uptake (B)
Water Temp	°C	27.07	27.07	27.36	27.11
Salinity	PSU	26.3	26.25	26.25	26.14
pH		8.39	8.49	8.5	8.39
Turbidity	NTU	5.09	6.69	13.62	6.47
DO	mg/l	5.69	6.44	6.58	6.79
ORP	mV	169	179	162	181
TSS	mg/L	1.3	1.3	1.3	2.4
POC	mg/L	0.1	0.1	0.2	0.3

		Treated			Control
	Unit	Discharge (M)	Discharge (M)	Discharge (M)	Uptake (M)
Water Temp	°C	27.39	27.63	27.52	27.41
Salinity	PSU	26.21	26.19	26.19	26.23
pH		8.51	8.51	8.52	8.42
Turbidity	NTU	4.41	2.72	5.8	2.26
DO	mg/l	6.26	6.17	6.5	6.73
ORP	mV	160	169	157	169
TSS	mg/L	1.5	1.8	1.6	2
POC	mg/L	0.1	0.2	0.2	0.2

		Treated			Control
	Unit	Discharge (E)	Discharge (E)	Discharge (E)	Uptake (E)
Water Temp	°C	27.67	27.71	27.8	27.82
Salinity	PSU	26.15	26.03	26.15	26.21
pH		8.52	8.51	8.52	8.39
Turbidity	NTU	4.07	4.04	4.07	13.2
DO	mg/l	6.54	6.51	6.41	6.65
ORP	mV	175	171	170	178
TSS	mg/L	1.9	2.4	2.5	2.5
POC	mg/L	0.1	0.1	0.1	0.2

(6) Test cycle 6

Measurement results are shown in Table 5-6 Measurement results of water quality in test cycle 6. As test cycle 6, uptake and discharge works were performed on July 23rd and July 25th respectively.

Water temperature was between 26.83-26.96°C during uptake and 27.07-27.82°C during discharge. Salinity was between 25.89-26.18PSU during uptake and 26.03-26.302PSU during discharge. POC was 0.1-0.2 mg/L during uptake and 0.1-0.3 mg/L during discharge. TSS was between 3.6-4.7 mg/L during uptake and 1.3-2.5 mg/L during discharge.

Table 5-6 Measured results of water quality of test cycle-6

Test cycle 6 **Uptake** **23th July, 2009** **Discharge** **25th July, 2009**

	Unit	Uptake		
		Uptake (B)	Uptake (M)	Uptake (E)
Water Temp.	°C	27.2	27.15	26.89
Salinity	PSU	26.16	27.37	28.86
pH		8.24	8.19	8.11
Turbidity	NTU	7.19	6.89	7.82
DO	mg/l	6.64	6.54	6.25
ORP	mV	194	176	217
TSS	mg/L	5.7	4.7	4
POC	mg/L	0.4	0.3	0.2

	Unit	Treated			Control
		Discharge (B)	Discharge (B)	Discharge (B)	Uptake (B)
Water Temp	°C	26.98	27.08	27.13	27.02
Salinity	PSU	28.06	27.97	27.87	27.9
pH		8.11	8.13	8.14	8.09
Turbidity	NTU	8.51	6.66	3.18	9.19
DO	mg/l	5.69	6.08	5.69	6.02
ORP	mV	136	184	188	184
TSS	mg/L	3.6	5.1	5	2.8
POC	mg/L	0.3	0.1	0.1	0.5

	Unit	Treated			Control
		Discharge (M)	Discharge (M)	Discharge (M)	Uptake (M)
Water Temp	°C	27.37	27.39	27.44	27.57
Salinity	PSU	27.68	27.61	27.56	27.53
pH		8.15	8.16	8.16	8.1
Turbidity	NTU	7.61	4.14	4.66	3.08
DO	mg/l	6.17	5.95	5.51	5.88
ORP	mV	194	194	180	182
TSS	mg/L	4.7	4.7	4.9	3.4
POC	mg/L	0.2	0.3	0.1	0.1

	Unit	Treated			Control
		Discharge (E)	Discharge (E)	Discharge (E)	Uptake (E)
Water Temp	°C	27.48	27.56	27.47	27.64
Salinity	PSU	27.5	27.43	27.22	27.36
pH		8.16	8.17	8.17	8.11
Turbidity	NTU	9.33	7.78	3.5	2.7
DO	mg/l	6.18	6.48	6.37	5.93
ORP	mV	191	191	189	184
TSS	mg/L	5	6.5	5.4	2.6
POC	mg/L	0.3	0.5	0.6	0.5

Rokko-island is located the northern part of Osaka bay and the surround water has hard bay-characteristic. Measured temperature value was higher than the existent one in the center of the bay. And salinity value showed lower than usual because of the effect of river water.

POC values showed lower generally and the value of discharge is lower than the intake.

TSS values showed regular as the average coast data and the value of discharge is lower than intake. It suggests that the suspended matter became lower by the ballast water treatment.

4.4 Other measurement results

(1) Variation of DO by ballast water treatment

Effect of the addition of sodium sulfite used as neutralizating agent on DO discharged coastal water body was pointed out by GESAMP-BWWG at the reviewing process of G9 basic approval application. DO concentration in discharged treated ballast water was measured using water quality meter during these onboard tests and was confirmed using saturation calculated by Weiss's equation.

Measured DO saturation values in discharged ballast water are shown in Table 6. Although slight decrease can be seen compared to uptaking state, the saturation of discharge water shows more than 80%. Considering the dilution by environmental water after discharge into water, it can be judged that there is no apparent effect to aquatic organisms.

Table 6 Measured DO saturation values in discharged ballast water

	Dischrge		Uptake
Test Cycle	Minimum Value (%)	Maximum Value (%)	(%)
1	99	103	109
2	99	103	103
3	92	100	107
4	80	92	94
5	83	99	105
6	82	91	95

(2) Information on meteorological and hydrographic phenomenon during onboard test period

Outline of the information on meteorological and hydrographic phenomenon during onboard test period, from July 18th to July 25th, are shown in Table 7.

Table 7 Meteorological phenomenon during onboard test period

Month/Day	Atospheric Temperature (°C)	Most frequent wind direction	Mean wind velocity (m/s)	Precipitation amount (mm)
July 18th	26.4	SW	5.4	0.0
July 19th	26.1	SW	5.8	62.0
July 20th	25.7	W	2.9	18.0
July 21st	25.3	SW	3.8	16.0
July 22nd	25.6	WSW	3.5	5.5
July 23rd	27.1	ENE	4.1	0.0
July 24th	26.8	W	2.7	0.0
July 25th	26.0	SE	4.4	30.5

Tidal level fluctuation during test period were middle tide from 18th to 20th, spring tide from 21st to 23rd, and middle tide from 24th and 25th. The lowest tide during spring tide was early in the afternoon and corresponded to uptaking perid.

According to the red tide occurence status in Hyogo Prefecture on July 29th, Red tide composed of diatom complex occurred along the coast of Kobe city to Nishinomiya city but the density of organisms did not reach the red tide condition during test period.

5. Conclusions

In these onboard tests, requirements for (1) Test cycle, (2) Effective standard of the test, (3) Standards for approval, (4) Sample number, (5) Sample volume and (6) Measuring items for water quality were all fulfilled.

It is required that one test cycle should consist of consecutive works of water uptake, storage and discharge. These onboard tests which started from July 18th were performed with water uptaking on 1st day and discharging on 3rd day after 2day storage period.

Effective standaeds of the test is that density of aquatic organisms should be more than 10 times of regulation D2 during uptake and more than regulation D2 for control water during discharge. In uptaken water, density of L size group organisms were 28,982-336,713,ind./m^3 and S size group were 680-2,210 ind./ml in these onboard tests. As these results of all test cycles fulfilled the above standard, all six test cycles were evaluated as "Effective test cycles".

In regard to regulation D2, bio-efficacy test results of L size group organisms for all test cycles fulfilled regulation D-2. Even though survived organisms in treated ballast water during discharge were found from the 1st to 3rd test cycle, no survived organisms found after 4th test cycle. *Halpacticoida* (Copepod), found in treated ballast water at the initial tests, are the species living in bottom sediment and did not appeare in uptake water. Hence, it can be considered that these were living in the bottom sediment in ballast water tanks, mixed in during discharge and survived because of quick neutralization at discharge.

Bio-efficacy test results of S size group organisms for all test cycles also fulfilled regulation D-2. Survived organism was only genus *Scrippsiella* (Dinoflagellate) appeared in 1st test cycle.

In regard to bacteria, results of all test cycles fulfilled regulation D-2. Results of *Esherichia Coli* were all 0 cfu/100ml for D-2.2 standard limit 250 cfu/100ml. In regard to Intestinal Enterococci, measurement results of *Enterococcus* group for all test cycles were all 0 cfu/100ml for D-2.2 standard limit 100 cfu/100ml. In regard to Toxicogenic *Vibrio Cholerae*, measurement results of genus *Vibrio* showed some colonies in treated water, however the existance of *Vibrio cholerae* was denied in 2nd screening process and then the existance of Toxicogenic *Vibrio cholerae* was all denied before 3rd screening process.

Sample number and sample volume were fulfilled more than required.

As to water quality items, more items and numbers than the IMO guidelines were measured. Water temperature was between 16 and 28°C, salinity between 25 and 29 PSU, TSS between 3.4 and 5.7 mg/L and POC between 0.1 and 0.9 mg/L. Moreover, pH, turbidity DO and ORP were also measured and these values for discharge water did not show any abnomal differences to uptake water.

As stated above, all results of the onboard test measurement for six test cycles fulfill the standards defined in IMO guideline G8 and also fulfill the approval standards for "three consecutive effective

test cycles".